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ECOLOGY, ENVIRONMENT AND DISASTER MANAGEMENT

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BIOSPHERE AND WORKING OF ECOSYSTEMS

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1. BIOSPHERE AND WORKING OF ECOSYSTEMS

1.1. BIOSPHERE

Biosphere is that part of lithosphere, hydrosphere and atmosphere where plants and human beings live. Biosphere contains all life forms on earth.

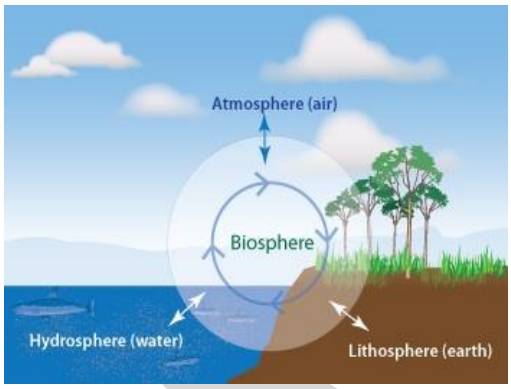


Figure 1: BIOSPHERE

The biosphere consists of all the living organisms (the biotic component), energy and physical environment (the abiotic component) and there are continuous interactions between living organisms and physical environment and among the living organisms themselves.

- The biosphere consists of two major systems viz. (i) terrestrial biomes systems and (ii) aquatic biomes systems.
- The terrestrial biomes systems are further comprised of three subsystems viz., (i) plant system, (ii) animal system and (iii) soil system. These subsystems are intimately interrelated among themselves through the cyclic pathways of movements and transfer of energy and materials.
- The aquatic biomes systems are also composed of three sub-systems viz. : (i) Plant system, (ii) Animal system, and (iii) Nutrients. These three sub-systems of aquatic biomes system of the biosphere are also intimately interrelated through cyclic pathways of movements of energy and matter among themselves.
- Man depends on biosphere to fulfill many of his needs like food, drugs, clothes, housing, paper and tourism and environment.

1.2. ECOLOGY

Ecology can be defined as a scientific study of the interactions of organisms with their physical environment and with each other.

The term ecology is derived from the Greek word 'oikos' meaning 'house', combined with the word 'logy' meaning the 'science of' or 'the study of '. Literally, ecology is the study of the earth as a 'household', of plants, human beings, animals and micro-organisms. They all live together as interdependent components.

A German zoologist Ernst Haeckel, who used the term as 'oekologie' in 1869, became the first person to use the term 'ecology'. The study of interactions between life forms (biotic) and the physical environment (abiotic) is the science of ecology.

1.3. ECOSYSTEM

An ecosystem is a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.

1.3.1. COMPONENTS OF ECOSYSTEM

There are four basic components of an ecosystem.

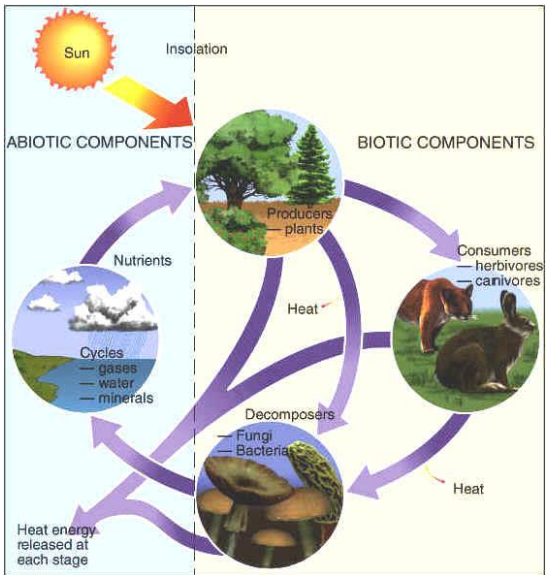


Figure 2: Ecosystem and its components

1. The abiotic part, which is the non-living environment.
2. The producers or autotrophs, the green plants capable of producing their own food by using the energy of sunlight to make carbohydrates from water and carbon dioxide; this process is called photosynthesis.
3. There are the consumers or heterotrophs. These are animals which obtain their food by eating plants or other animals. The heterotrophs in any ecosystem can be divided into groups by their feeding habits:

- herbivores eat only living plant material;
- Detritivores feed on dead plant and animal material;
- Carnivores eat other animals;
- Omnivores eat both plant and animal material.

4. Decomposers, such as the bacteria and fungi that promote decay.

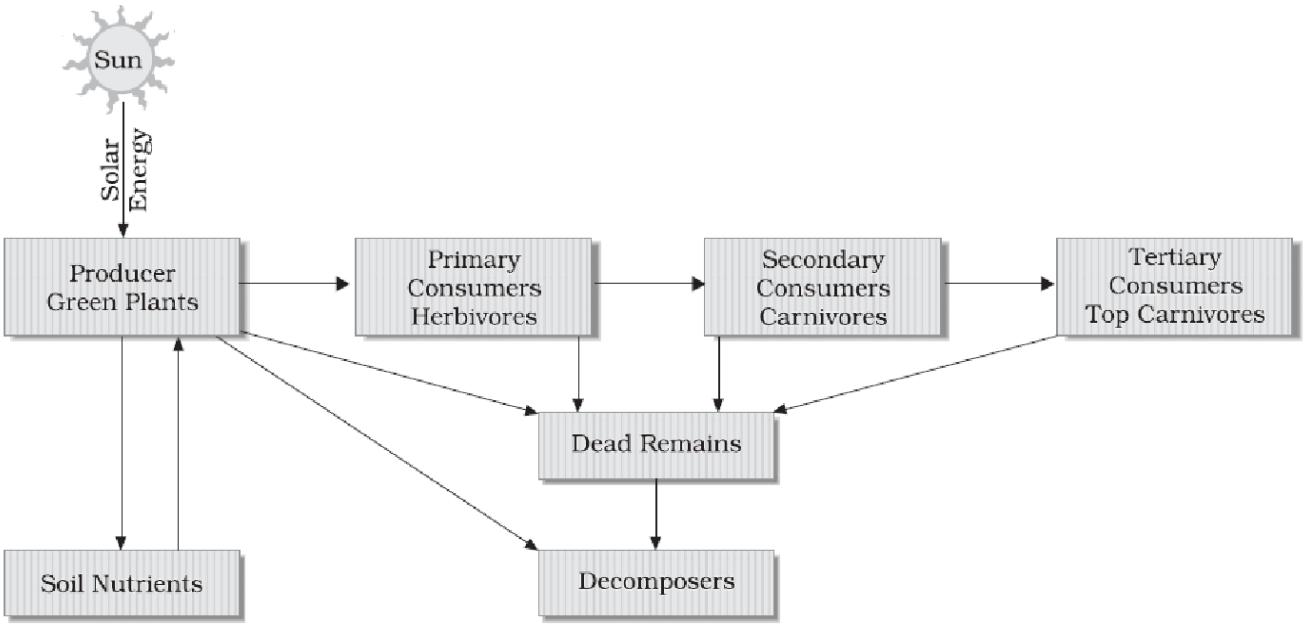


Figure 3: Structure and Functions of Ecosystem

1.3.2. TYPES OF ECOSYSTEM

Ecosystem varies greatly in size from a small pond to a large forest or a sea. Many ecologists regard the entire biosphere as a global ecosystem, as a composite of all local ecosystems on Earth. Since this system is too much big and complex to be studied at one time, it is convenient to divide it into two basic categories, namely the terrestrial and the aquatic.

- **Terrestrial Ecosystem**
  - The ecosystem which is found only on landforms is known as the terrestrial ecosystem.
  - The main factor which differentiates the terrestrial ecosystems from the aquatic ecosystems is the relative shortage of water in the terrestrial ecosystems and as a result the importance that water attains in these ecosystems due to its limited availability.
  - Another factor is the better availability of light in these ecosystems as the environment is a lot cleaner in land than it is in water.
  - The main types of terrestrial ecosystems are the forest ecosystems, the desert ecosystems, the grassland ecosystems and the mountain ecosystems.
- **Aquatic Ecosystem**
  - An ecosystem which exists in a body of water is known as an aquatic ecosystem.
  - The aquatic ecosystems are mainly of two types, the freshwater ecosystems and the marine ecosystems.

1.3.3. ENERGY FLOW IN ECOSYSTEM

Sun is the primary source of energy for all ecosystems on Earth. Of the incident solar radiation less than 50 per cent of it is **photosynthetically active radiation** (PAR). Photosynthetically active radiation, often abbreviated **PAR**, designates the spectral range (wave band) of solar radiation from 400 to 700 nanometers that photosynthetic organisms are able to use in the process of photosynthesis.

Plants capture only 2-10 per cent of the PAR and this small amount of energy sustains the entire living world. The energy of sunlight fixed in food production by green plants is passed through the ecosystem by food chains and webs from one trophic level to the next. In this way, energy flows through the ecosystem.

1.3.3.1. The Trophic Structure of Ecosystems

- The organisation and pattern of feeding in an ecosystem is known as the trophic structure.
- The levels through which food energy passes from one group of organism to the other group are called trophic levels.

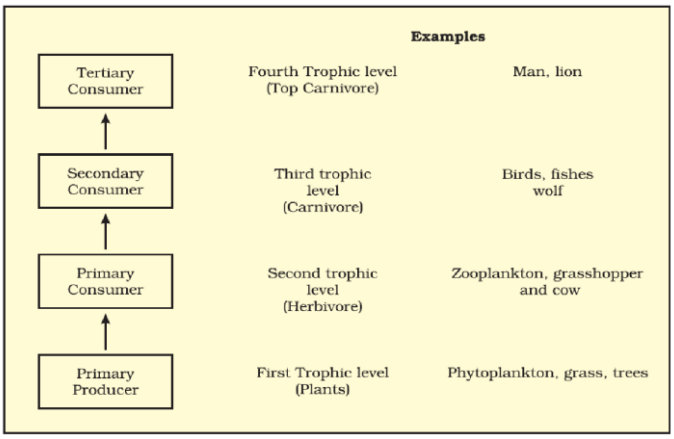


Figure 4: Tropic levels in an ecosystem

Food Chain

The chain of transformation and transfer of food energy in the ecosystem from one group of organism to another group through a series of steps or levels is called food chain.

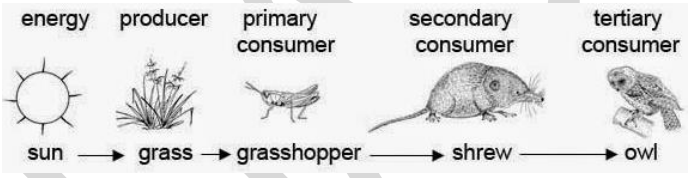


Figure 5: A Food Chain

Two types of food-chains are recognised:

1. **Grazing food-chain:** In a grazing food-chain, the first level starts with plants as producers and ends with carnivores as consumers at the last level, with the herbivores being at the intermediate level. There is a loss of energy at each level which may be through respiration, excretion or decomposition. The levels involved in a food chain range from three to five and energy is lost at each level. The phytoplanktons →zooplanktons →Fish sequence or the grasses →rabbit →Fox sequences are the examples, of grazing food chain.
2. **Detritus food chain:** This type of food chain goes from dead organic matter into microorganisms and then to organisms feeding on detritus (detrivores) and their predators. Such ecosystems are thus less dependent on direct solar energy. These depend chiefly on the influx of organic matter produced in another system. For example, such type of food chain operates in the decomposing accumulated litter in a temperate forest.

Food Web

When the feeding relationship in a natural ecosystem become more complicated, the food chain does not remain simple and linear rather it is also complicated by several inter-connected overlapping food chains. This happens when greater number of species feed on many kinds of prey.
Such complicated food chain is called food web.

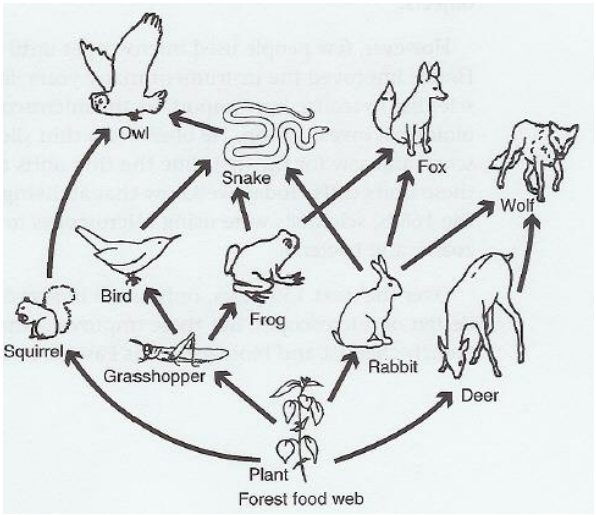


Figure 6: A Food Web

- Thus, Energy is passed through the system in food chains and webs. The flow of energy in ecosystems is unidirectional.
- The important point to note is that the amount of energy decreases at successive trophic levels. The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows **10 per cent law** – only 10 per cent of the energy is transferred to each trophic level from the lower trophic level.
    - Storage of energy in the system is shown by the amount of living material in both the plants and animals present. The amount of living material present is called the standing crop.

- This can be expressed in several ways but is usually shown as biomass (living material) per unit area, measured as dry weight, ash weight or calorific value.
- Usually the amount of standing crop in each trophic level decreases with each step on the food chain away from the plants. This can be shown diagrammatically by Ecological pyramids.

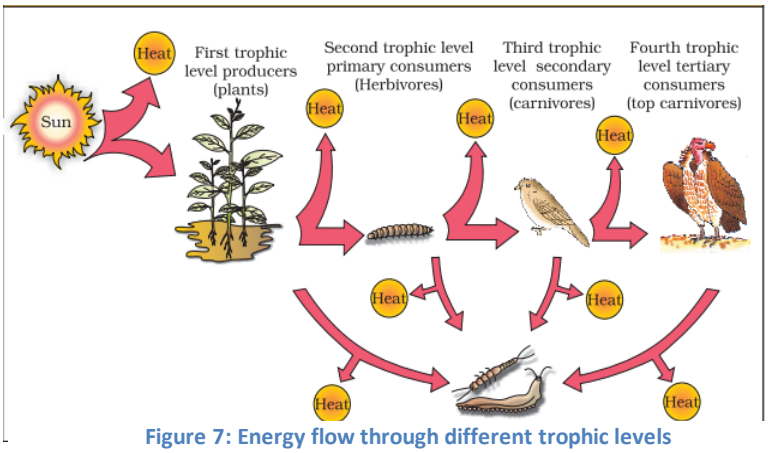


Figure 7: Energy flow through different trophic levels

Ecological Pyramid

The pyramid shape of decrease of total number of species, total biomass and energy availability with successive higher trophic levels in the food chain in a natural ecosystem is called ecological pyramid.

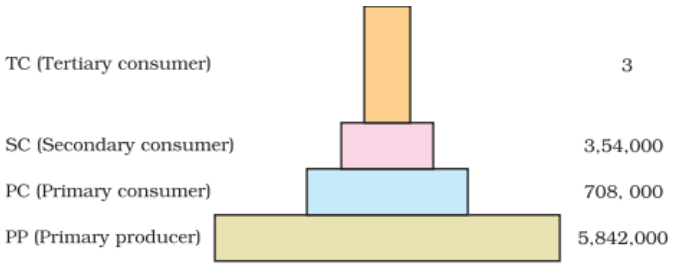


Figure 8: *Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 million plants*

- The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top level consumer. The three ecological pyramids that are usually studied are:
  a) **pyramid of number;**
  b) **pyramid of biomass and**
  c) **pyramid of energy**.
- Number Pyramid is the pyramid formed by the number of species from one trophic level to higher trophic levels.
- Biomass pyramid includes the total weight of the organic matter (total biomass) of each trophic level. Thus, the pyramid formed by total biomass at each trophic level is called biomass pyramid.
- Energy Pyramid is the pyramid representing total amount of energy present at each trophic level of food chain in a natural ecosystem per unit area per unit time. The energy is expressed in kilocalories per square meter per day or per year. (Kcal/m^2/day or year)

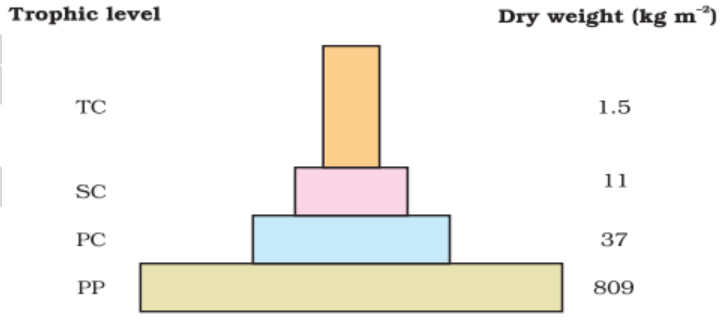


Figure 9: *Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels*

Any calculations of energy content, biomass, or numbers has to include all organisms at that trophic level. No generalisations we make will be true if we take only a few individuals at any trophic level into account.

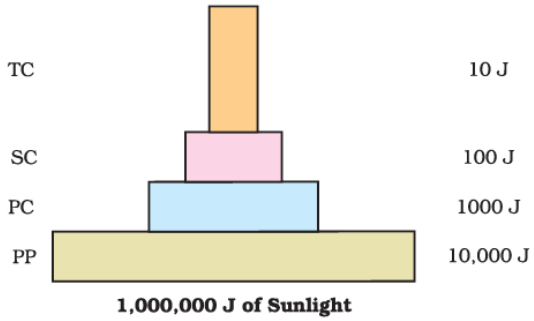


Figure 10: *An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP*

- A given organism may occupy more than one trophic level simultaneously. One must remember that the trophic level represents a functional level, not a species as such. A given species may occupy more than one trophic level in the same ecosystem at the same time; for example, a sparrow is a primary consumer when it eats seeds, fruits, peas, and a secondary consumer when it eats insects and worms.
- In most ecosystems, all the pyramids, of number, of energy and biomass are upright, i.e., producers are more in number and biomass than the herbivores, and herbivores are more in number and biomass than the carnivores. Also energy at a lower trophic level is always more than at a higher level.
- There are exceptions to this generalisation, for example the number of insects feeding on a big tree.

- The pyramid of biomass in sea is also generally inverted because the biomass of fishes far exceeds that of phytoplankton.
- Pyramid of energy is always upright, can never be inverted, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step

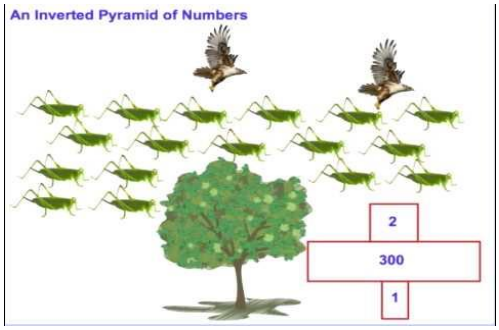


Figure 101: *Inverted pyramid of biomass-small standing crop of phytoplankton supports large Standing crop of zooplankton*

1.3.4. PRODUCTIVITY

In ecosystems the rate of production of organic matter is known as productivity.

Primary productivity refers to production at the autotroph level, and secondary productivity refers to production at the heterotroph level.

Productivity can be further divided into gross and net. Gross productivity is the total amount of organic matter produced, and net productivity is the amount of organic matter left after some has been used in respiration.

Primary gross productivity will depend on the efficiency of photosynthesis and the amount of light energy coming into the system. The intensity and duration of sunlight varies globally so that the potential for gross primary productivity will vary greatly with different ecosystems.

Secondary productivity will depend on the conversion of plant substances to animal substances. The efficiency of transfer of energy from one trophic level to the next is known as ecological efficiency.

Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, availability of nutrients and photosynthetic capacity of plants. Therefore, it varies in different types of ecosystems.

The table below shows representative values for the net productivity of a variety of ecosystems — both natural and managed. These values are only approximations and are subject to fluctuations because of variations in temperature, fertility, and availability of water

	Estimated Net Productivity of Certain Ecosystems (in kilocalories/m^2/year)
15,000	Tropical rain forest
12,000	Coastal marsh
5,000	Temperate deciduous forest
2,500	Ocean close to shore
2,000	Tall-grass prairie
800	Open ocean
500	Desert

1.3.5. ECOLOGICAL NICHE

The role that an organism takes in the ecosystem is known as its ecological niche. Species vary in the breadth of the roles performed. Some animals are specialists in their feeding habits-such as the koala bear, which eats only eucalyptus leaves—and others are generalists, consuming a wide variety of food.

The majority of animals occupy a broad ecological niche and so are generalists in their feeding habits.

1.3.6. HABITAT

The ecological niche of a species may vary through its distribution in relation to its habitat, which is the name given to the place where an organism lives.

Factors such as availability of different foods and competition from other species will influence the role of an individual. Man is an example of this, operating as a herbivore, a carnivore and an omnivore in different places.

1.3.7. SPECIES STRUCTURE

The species structure of an ecosystem refers to the numbers of species present, their relative abundance and diversity. Characteristically ecosystems contain a few species that are relatively common, having large numbers in their populations or a large amount of biomass in their standing crop, and a large number of species that are rare. Details about species structure will be taken up in next chapter.

1.3.8. DECOMPOSITION

Decomposition is the natural process of dead animal or plant tissue being rotted or broken down.
This process is carried out by invertebrates, fungi and bacteria. The result of decomposition is that the building blocks required for life can be recycled. Some dead animals will be eaten by scavenging animals such as foxes or crows.

- Those which are not eaten by larger animals are quickly decomposed or broken down into their constituent chemicals by a host of creatures including beetles and their larva, flies, maggots and worms as well as bacteria, moulds and fungi. Collectively these are known as decomposers.
- The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation.
- Detritivores (e.g., earthworm) break down detritus into smaller particles. This process is called fragmentation.
- By the process of leaching, water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.

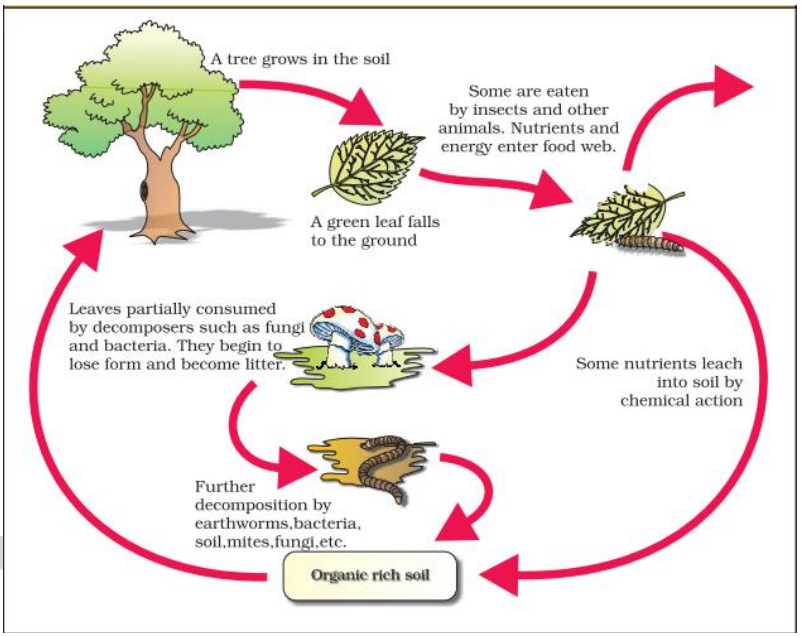


Figure 12: ***Diagrammatic representation of decomposition cycle in a terrestrial ecosystem***

- Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as catabolism.
- It is important to note that all the above steps in decomposition operate simultaneously on the detritus (raw material for decomposition).
- Humification and mineralisation occur during decomposition in the soil.
- Humification leads to accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. Being colloidal in nature it serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occurs by the process known as mineralization.
- Decomposition is largely an oxygen-requiring process.

The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition, decomposition rate is slower if detritus is rich in lignin and chitin and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars. Temperature and soil moisture are the most important climatic factors that regulate decomposition through their effects on the activities of soil microbes. Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in builds up of organic materials.

1.3.9. BIOMAGNIFICATION

Biomagnification, also known as bioamplification, is the process by which substances become more concentrated in the bodies of consumers as one moves up the food chain (trophic levels).

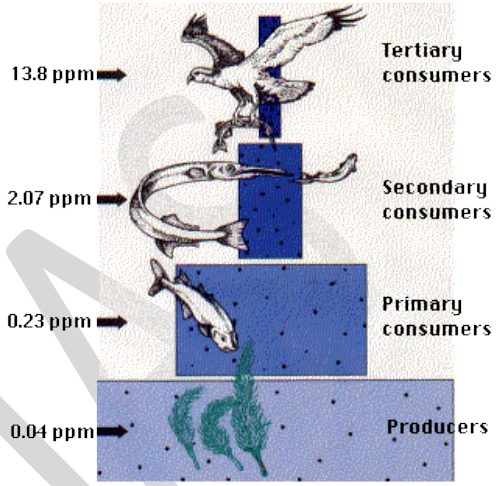
When chemicals or pesticides are let into rivers or lakes they are consumed by aquatic organisms like fish, which in turn are consumed by large birds, animals or humans. These harmful substances become concentrated in tissues, internal organs as it moves up the food chain.

Following substances have the potential to biomagnify:

1. *Polychlorinated Biphenyls* used as insulators in transformers and fire retardants.
2. *Polynuclear aromatic hydrocarbons* which are present in petroleum products.
3. *Heavy metals* like Mercury, copper, cadmium, chromium, lead, nickel, zinc, tin (TBT or tributyltin).
4. *Cyanides* used in fishing and gold leaching.

Effects of biomagnification:

1. High concentrations of DDT in some bird species caused failure of eggs by thinning the shells.
2. PCBs can affect the immune system, fertility, child development and possibly increase the risk of certain cancers.
3. Mercury poisoning interferes with the nervous system development in fetuses and young children.



The numbers are representative values of the concentration in the tissues of **DDT** and its derivatives (in parts per million, ppm)

Figure 13: ***How DDT becomes concentrated in the tissues of organisms representing four successive trophic levels in a food chain.***

1.3.5.1. Bioaccumulation v/s Biomagnification

- Although sometimes used interchangeably with bioaccumulation, an important distinction between the bioaccumulation and biomagnifications is that bioaccumulation occurs within a trophic level, and is the increase in concentration of a substance in certain tissues (usually in fatty tissue.) of organisms' bodies due to absorption from food and the environment.
- The longer the half-life of the substance the greater is the risk of poisoning though levels of toxins are not very high in the environment. Bioaccumulation varies between individual organisms as well as between species. Large, fat, long-lived individuals or species with low rates of metabolism or excretion of a chemical will bioaccumulate more than small, thin, short-lived organisms. Thus, an old lake trout may bioaccumulate much more than a young bluegill in the same lake.

1.4. NUTRIENT CYCLES

The flow of energy in ecosystems is one-way. In contrast, the nutrients which are needed to produce organic material are circulated round the system and are re-used several times.

- All natural elements are capable of being absorbed by plants, usually as gases from the air or as soluble salts from the soil, but only oxygen, carbon, hydrogen and nitrogen are needed in large quantities. These substances are known as macronutrients and form the basis of fats, carbohydrates and proteins.
- Other nutrients, such as magnesium, sulphur and phosphorus are needed in minute amounts and are known as micronutrients.
- Nutrient cycles can be presented in the framework of a model in which each cycle has a reservoir pool, which is a large, slow-moving non-biological component, and an exchange pool, which is a smaller, more active portion where the nutrient is exchanged between biotic and abiotic parts of the ecosystem. There are two basic types of cycle, **gaseous ones**, in which the reservoir pool is the atmosphere, and **sedimentary** ones, in which the reservoir pool is the Earth's crust.
- Another name of nutrient cycling is biogeochemical cycles (bio: living organism, geo: rocks, air, and water).

1.4.1. Water Cycle

- Water undergoes a cycle from the ocean to land and land to ocean.
- The hydrological cycle describes the movement of water on, in, and above the earth.

- The distribution of water on earth is quite uneven. Many locations have plenty of water while others have very limited quantity.
- The hydrological cycle is the circulation of water within the earth's hydrosphere in different forms i.e. the liquid, solid and the gaseous phases.

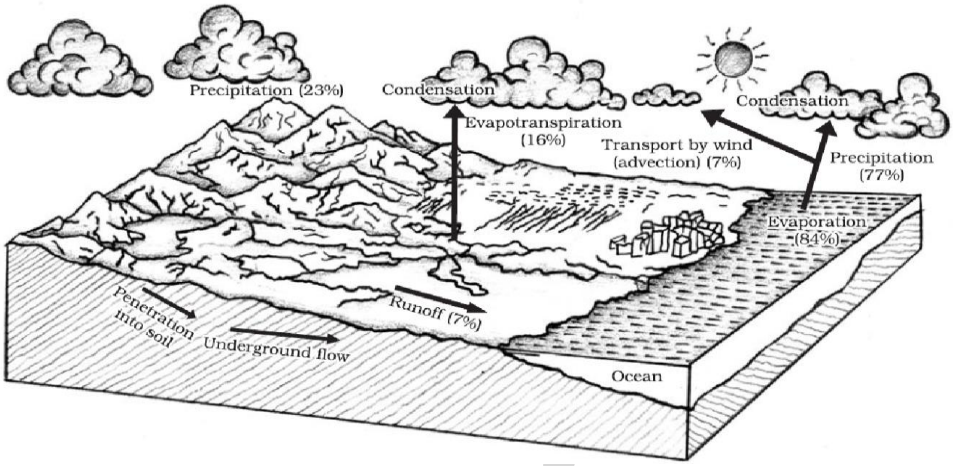
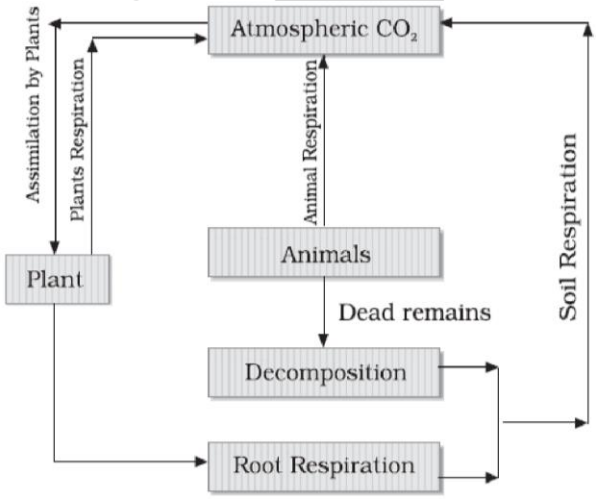


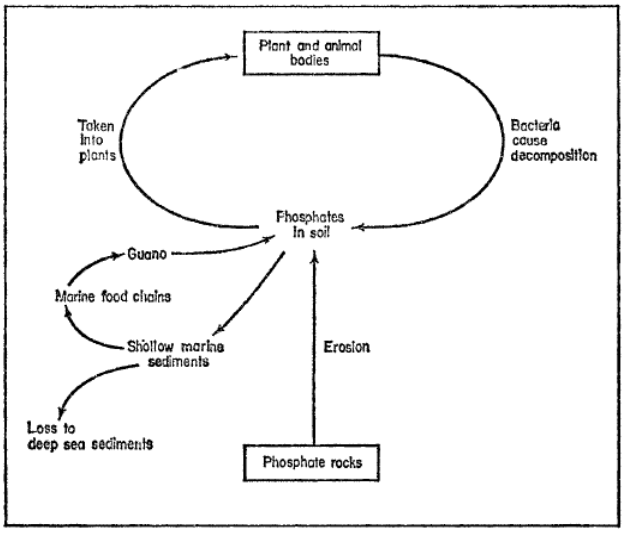
Figure 14: Water Cycle

About 71 per cent of the planetary water is found in the oceans. The remaining is held as freshwater in glaciers and icecaps, groundwater sources, lakes, soil moisture, atmosphere, streams and within life. Nearly 59 per cent of the water that falls on land returns to the atmosphere through evaporation from over the oceans as well as from other places. The remainder runs-off on the surface, infiltrates into the ground or a part of it becomes glacier.

1.4.2. Carbon Cycle



- Carbon cycle is mainly the conversion of carbon dioxide.
- This conversion is initiated by the fixation of carbon dioxide from the atmosphere through photosynthesis.
- Such conversion results in the production of carbohydrate, glucose that may be converted to other organic compounds.
- Some of the carbohydrates are utilised directly by the plants itself.
- During the process, more Carbon dioxide is generated and is released through its leaves or roots during the day.
- The remaining carbohydrates not being utilised by the plant become part of the plant tissue.
- Plant tissues are either being eaten by the herbivorous animals or get decomposed by the microorganisms.
- The herbivores convert some of the consumed carbohydrates into carbon dioxide for release into the air through respiration.
- The micro-organisms decompose the remaining carbohydrates after the animal dies.
- The carbohydrates that are decomposed by the micro-organisms then get oxidised into carbon dioxide and are returned to the atmosphere.



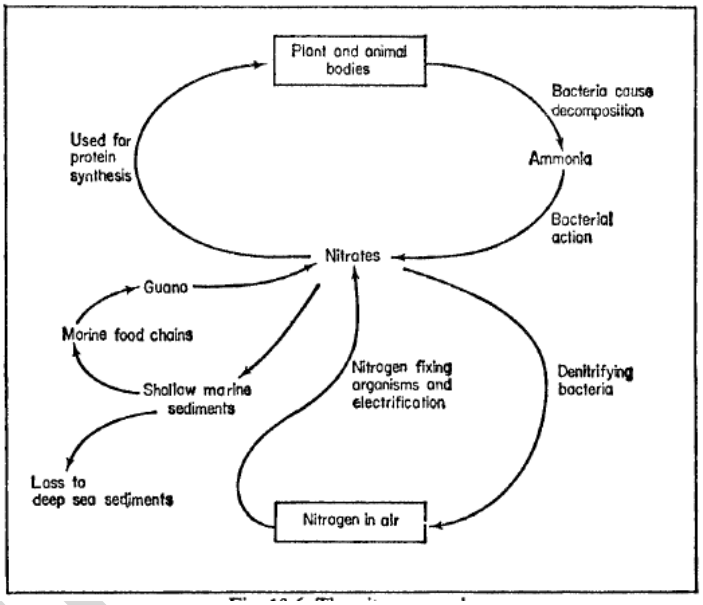
1.4.3. The Phosphorus Cycle

- The phosphorus cycle is an example of a sedimentary cycle which is easily disrupted.
- Phosphates in the soil are taken into plants for protein synthesis and are passed through the food chains of ecosystems.
- When plant and animal bodies and their excretory products decompose, the phosphorus is released to the soil where it can either be taken back into plants or washed out by rainfall into drainage systems which ultimately take it to the sea.
- If this happens it will be incorporated in marine sediments and so lost from the exchange pool.

- One important route for the rapid return of phosphorus from these sediments occurs where there are upwelling ocean currents. These bring phosphorus to the surface waters, where it is taken into marine food chains.
- The depletion of phosphorus from the exchange pool is compensated very slowly by the release of the element from the phosphate rocks of the reservoir pool. This occurs by the process of erosion and weathering.
- The phosphorus cycle can be easily disrupted by the use of phosphate fertilisers in modern agriculture.
- Most manufactured phosphate fertilisers are produced from phosphate rocks but are rapidly lost from the exchange pool to marine deposits as they are easily leached from the soil.

1.4.4. The Nitrogen Cycle

- The nitrogen cycle is an example of a gaseous type.
- It is probably the most complete of the nutrient cycles.
- The reservoir pool is the atmosphere and the exchange pool operates between organisms and the soil.
- Atmospheric nitrogen in the reservoir pool cannot be used directly by most plants. It has to be made into a chemical compound such as a nitrate before it is available to the exchange pool.
- Nitrates in the soil are absorbed by plants and pass through food chains.
- Ultimately they are released as ammonia when organic material is decomposed.
- The ammonia is changed back to nitrates by the action of bacteria.



- If the nitrates are not reabsorbed by plants they may be lost from the exchange pool in two ways: first, by leaching from the soil to shallow marine sediments (in this case they may be returned in the droppings of marine birds in the same way as phosphorus); second, nitrates may be lost from the soil by being broken down by denitrifying bacteria, and the nitrogen contained in them being released to the atmosphere.
- The conversion of gaseous nitrogen to nitrate occurs in two main ways. Some can be fixed by electrical action during thunderstorms, but most is converted by nitrogen-fixing organisms. These are mostly bacteria, algae and fungi, and either operates by themselves in the soil or in an association with a plant, particularly those in the legume family, such as clover.

1.4.5. The Oxygen Cycle

The cycling of oxygen is a highly complex process. Oxygen occurs in a number of chemical forms and combinations.

It combines with nitrogen to form nitrates and with many other minerals and elements to form various oxides such as the iron oxide, aluminium oxide and others.

Much of oxygen is produced from the decomposition of water molecules by sunlight during photosynthesis and is released in the atmosphere through transpiration and respiration processes of plants.

1.4.6. Other Mineral Cycles

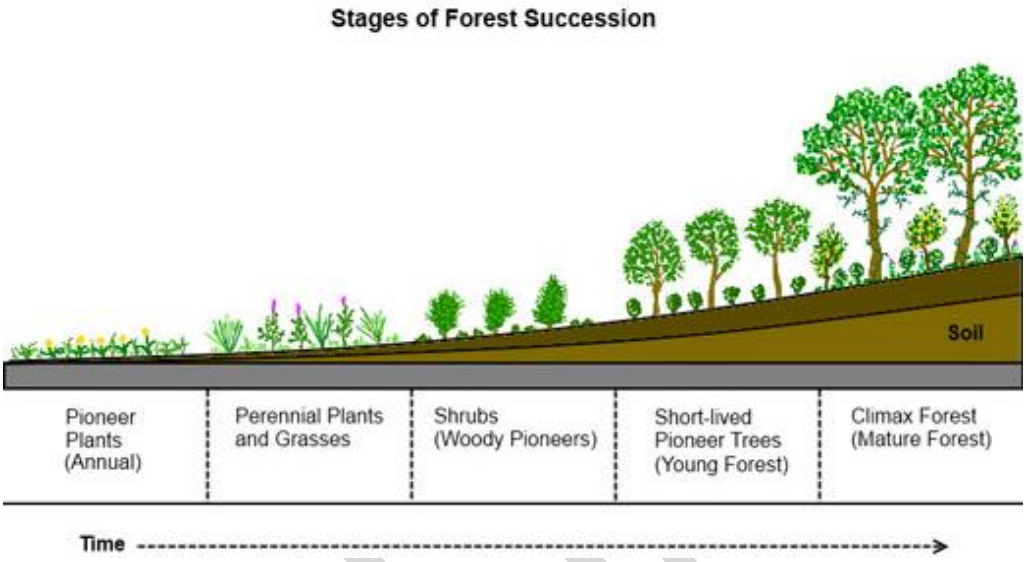
Other than carbon, oxygen, nitrogen and hydrogen being the principal geochemical components of the biosphere, many other minerals also occur as critical nutrients for plant and animal life. These mineral elements required by living organisms are obtained initially from inorganic sources such as phosphorus, sulphur, calcium and potassium.

They usually occur as salts dissolved in soil water or lakes, streams and seas. Mineral salts come directly from the earth's crust by weathering where the soluble salts enter the water cycle, eventually reaching the sea.

Other salts are returned to the earth's surface through sedimentation, and after weathering, they again enter the cycle. All living organisms fulfil their mineral requirements from mineral solutions in their environments. Other animals receive their mineral needs from the plants and animals they consume. After the death of living organisms, the minerals are returned to the soil and water through decomposition and flow.

1.5. SUCCESSION

- The species structure of an ecosystem will not be constant.
- There will be changes in the types of plants and animals living there as conditions are ameliorated by the organisms themselves. Typically there will be a sequence of different assemblages of species, each known as a seral stage or sere; each seral stage will alter the environment slightly.



- New species will migrate into the area as conditions change to those which they can tolerate.
- Change of community structure due to environmental change through time in this way is called succession. Succession is an orderly process involving predictable changes in species structure leading to a stable, self perpetuating community, called the climax.
- There are two main types of succession, primary and secondary.
- Primary succession is the series of community changes which occur on an entirely new habitat which has never been colonized before. For example, a newly quarried rock faces or sand dunes. The establishment of a new biotic community is generally slow. Before a biotic community of diverse organisms can become established, there must be soil. Depending mostly on the climate, it takes natural processes several hundred to several thousand years to produce fertile soil on bare rock.
- Secondary succession is the series of community changes which take place on a previously colonized, but disturbed or damaged habitat. For example, after felling of trees in woodland, land clearance or a fire. Since some soil or sediment is present, succession is faster than primary succession.

1.5.1. SERE

Succession is directional. Different stages in a particular habitat succession can usually be accurately predicted. These stages, characterised by the presence of different communities, are known as 'seres'. Communities change gradually from one sere to another.

1.5.2. CLIMAX

- The seres are not totally distinct from each other and one will tend to merge gradually into another, finally ending up with a 'climax' community.
- The community developed at the end of succession is called climax vegetation or climax community.
- Succession will not go any further than the climax community. This is the final stage. This does not however, imply that there will be no further change. When large organisms in the climax community, such as trees, die and fall down, then new openings are created in which secondary succession will occur.
- At any time during primary or secondary succession, natural or human induced disturbances (fire, deforestation, etc.), can convert a particular stage of succession to an earlier stage.

- Also such disturbances create new conditions that encourage some species and discourage or eliminate other species.
- For example Grass ecosystems are an early stage of succession in regions where the mature ecosystems are forests. However, grass ecosystems are **climax ecosystems** in grassland regions, where there is not enough rainfall to support a forest. Desert ecosystems are climax ecosystems where there is not enough rainfall even for grassland. In some cases, there is enough rainfall for grass, but overgrazing can change the grassland to desert.

1.6. BIOTIC POTENTIAL

- Populations vary in their capacity to grow. The maximum rate at which a population can increase when resources are unlimited and environmental conditions are ideal is termed the population's biotic potential. Each species will have a different biotic potential due to variations in**:**
  - the species' reproductive span (how long an individual is capable of reproducing)
  - the frequency of reproduction (how often an individual can reproduce)
  - "litter size" (how many offspring are born each time)
  - survival rate (how many offspring survive to reproductive age)
- There are always limits to population growth in nature. Populations cannot grow exponentially indefinitely. Exploding populations always reach a size limit imposed by the shortage of one or more factors such as water, space, and nutrients or by adverse conditions such as disease, drought and temperature extremes.
- The factors which act jointly to limit a population's growth are termed the environmental resistance.

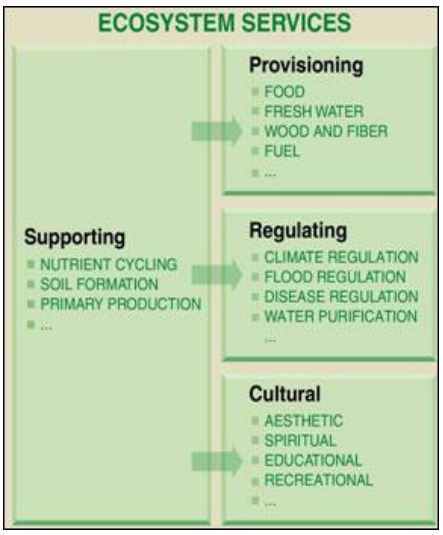
1.7. CARRYING CAPACITY

For a given region, carrying capacity is the maximum number of individuals of a given species that an area's resources can sustain indefinitely without significantly depleting or degrading those resources. Determining the carrying capacities for most organisms is fairly straightforward.

- For humans carrying capacity is much more complicated. The definition is expanded to include not degrading our cultural and social environments and not harming the physical environment in ways that would adversely affect future generations.
- For populations which grow exponentially, growth starts out slowly, enters a rapid growth phase and then levels off when the carrying capacity for that species has been reached.
- The size of the population then fluctuates slightly above or below the carrying capacity. Reproductive lag time may cause the population to overshoot the carrying capacity temporarily.
- Reproductive lag time is the time required for the birth rate to decline and the death rate to increase in response to resource limits.
- An area's carrying capacity is not static. The carrying capacity may be lowered by resource destruction and degradation during an overshoot period or extended through technological and social changes.

1.8. ECOSYSTEM SERVICES

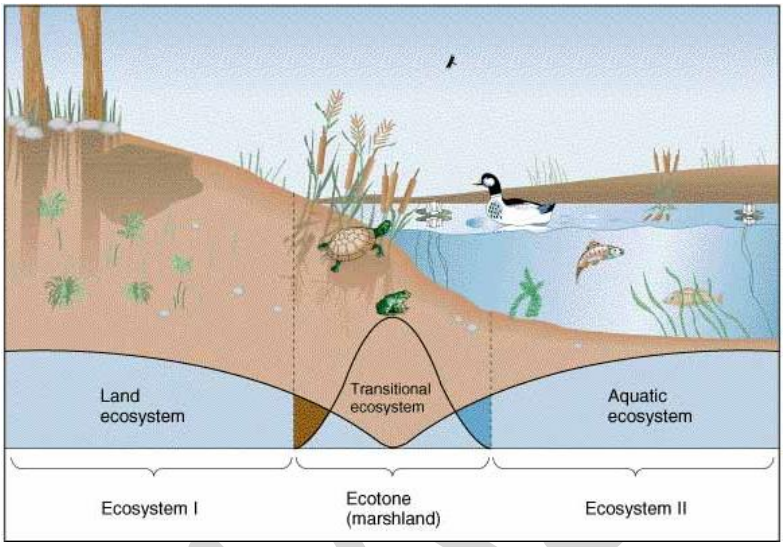
Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and supporting services needed to maintain the other services.



The Millennium Ecosystem Assessment (MA) was initiated in 2001 by United Nations. The objective of the MA was to assess the consequences of ecosystem change for human well-being, the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being.

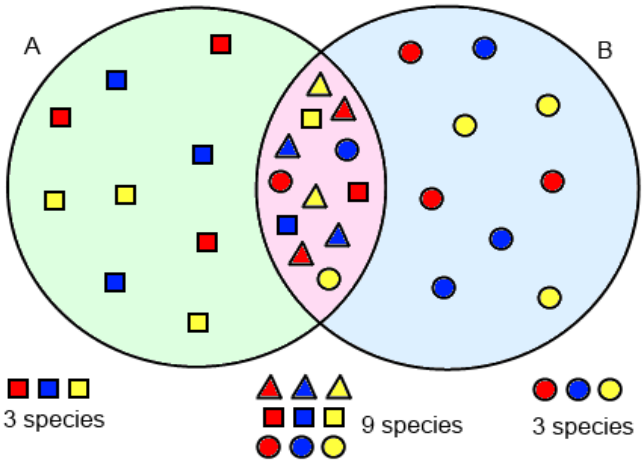
1.9. ECOTONE

An **ecotone** is a transitional area between two different ecosystems, such as a forest and grassland.



- It has some of the characteristics of each bordering biological community and often contains species not found in the overlapping communities.
- An ecotone may exist along a broad belt or in a small pocket, such as a forest clearing, where two local communities blend together.
- An ecotonal area often has a higher density of organisms of one species and a greater number of species than are found in either flanking community.
- Some organisms need a transitional area for activities such as courtship, nesting, or foraging for food.
- Ecotones also appear where one body of water meets another (e.g., estuaries and lagoons) or at the boundary between the water and the land (e.g., marshes).

1.9.1. EDGE EFFECT



- Ecotones often have a larger number of species and larger population densities than the communities on either side.
- This tendency for increased biodiversity within the ecotone is referred to as the "edge effect."
- Those species which occur primarily or most abundantly in the ecotones are called "edge" species.

1.9.2. HOME RANGE

- The home range of an animal is the area where it spends its time; it is the region that encompasses all the resources the animal requires to survive and reproduce.
- Competition for food and other resources influences how animals are distributed in space. Even when animals do not interact, clumped resources may cause individuals to aggregate

1.9.3. OTHER IMPORTANT TERMS:

Hologenic: Those animals which take their food through their mouths, such as big animals e.g. elephants, cows, camels, etc.

Parasites: Those animals which depend on other animals for their food and life.

Autecology: The study of relationship of individual species with the environment.

Synecology: The study of plant communities in relation to their habitats of a given ecosystem.

1.10. UPSC QUESTIONS RELATED TO ABOVE TOPICS

1. The states of Jammu and Kashmir, Himachal Pradesh and Uttarakhand are reaching the limits of their ecological carrying capacity due to tourism. Critically evaluate. (GS paper1, 2015)
2. Write in detail on the concept of biosphere as an ecosystem. (Geography Mains 2002)
3. Discuss the concept, components and functioning of an ecosystem. (Geography Mains 2001/200 words)
4. Define ecosystem and describe briefly its various components. (Geography Mains 1994)
5. Write short note on ecosystem. (Geography Mains 1986/200 words).

1.11. PRELIMS QUESTIONS

Food Chain

1. Which one of the following is the correct sequence of a food chain?(2014)

(a) Diatoms-Crustaceans-Herrings (b) Crustaceans-Diatoms-Herrings
(c) Diatoms-Herrings-Crustaceans (d) Crustaceans-Herrings-Diatoms

Correct Answer: (a)

2. With reference to the food chains in ecosystems, which of the following kinds of organism is/are known as decomposer organism/organisms? (2013)

1. Virus 2. Fungi 3. Bacteria

Select the correct answer using the codes given below:

(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Correct Answer: (b)

3. With reference to food chains in ecosystems, consider the following statements: (2013)

1. A food chains illustrates the order in which a chain of organisms feed upon each other.
2. Food chains are found within the populations of a species.
3. A food chain illustrates the numbers of each organism which are eaten by others.

Which of the statements given above is/are correct?

(a) 1 only (b) 1 and 2 only
(c) 1, 2 and 3 (d) None

Correct Answer: (a)

Ecosystem

4. Which one of the following is the correct sequence of ecosystems in the order of decreasing productivity? (2013)

(a) Oceans, lakes, grasslands, mangroves (b) Mangroves, oceans, grasslands, lakes
(c) Mangroves, grasslands, lakes, oceans (d) Oceans, mangroves, lakes, grasslands

Correct Answer: (c)

5. In the grasslands, trees do not replace the grasses as a part of an ecological succession because of- (2013)

(a) insects and fungi (b) limited sunlight and paucity of nutrients
(c) water limits and fire (d) None of the above

Correct Answer: (c)

6. What would happen if phytoplankton of an ocean is completely destroyed for some reason? (2012)

1. The ocean as a carbon sink would be adversely affected.
2. The food chains in the ocean would be adversely affected.
3. The density of ocean water would drastically decrease.

Select the correct answer using the codes given below:

(a) 1and 2 only (b) 2 only

(c) 3only (d) 1, 2 and 3

Correct Answer: (a)

7. The Millennium Ecosystem Assessment describes: The following major categories of ecosystem services—provisioning, supporting, regulating, preserving and cultural. Which one of the following is supporting service? (2012)

(a) Production of food and water (b) Control of climate and disease

(c) Nutrient cycling and crop pollination (d) Maintenance of diversity

In the context of ecosystem productivity, marine upwelling zones are important as they increase the marine productivity by bringing the-(2011)

1. Decomposer microorganism to the surface.
2. Nutrients to the surface.
3. Bottom-dwelling organisms to the surface.

Which of the statements given above is/are correct?

(a) 1 and 2 (b) 2 only

(c) 2 and 3 (d) 3 only

Correct Answer: (c)

8. If a tropical rain forest is removed, it does not regenerate quickly as compared to a tropical deciduous forest. This is because: (2011)

(a) The soil of rain forest is deficient in nutrients

(b) Propagules of the trees in a rain forest have poor viability

(c) The rain forest species are slow growing

(d) Exotic species invade the fertile soil of rain forest

Correct Answer: (a)

9. In the context of ecosystem productivity, marine upwelling zones are important as they increase the marine productivity by bringing the-(2011)

1. Decomposer microorganism to the surface.
2. Nutrients to the surface.
3. Bottom-dwelling organisms to the surface.

Which of the statements given above is/are correct?

(a) 1 and 2 (b) 2 only

(c) 2 and 3 (d) 3 only

Correct Answer: (b)

Ecology

10. Consider the following organisms: (2013)

1. Agaricus
2. Nostoc
3. Spirogyra

Which of the above is/are used as biofertilizer/biofertilizers?

(a) 1 and 2 (b) 2 only

(c) 2 and 3 (d) 3 only

Correct Answer: (b)

11. Which one of the following terms describes not only the physical space occupied by an organism, but also its functional role in the community of organisms? (2013)

(a) Ecotone
(b) Ecological niche
(c) Habitat
(d) Home range Ecology

Correct Answer: (b)

12. A pesticide which is a chlorinated hydrocarbon is sprayed on a food crop. The food chain is: Food crop – Rat - Snake - Hawk. In this food chain, the highest concentration of the pesticide would accumulate in which one of the following? (2010)

(a) Food crop
(b) Rat
(c) Snake
(d) Hawk

Correct Answer: (d)

BIODIVERSITY

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2. BIODIVERSITY

2.1. BIODIVERSITY MEANING

Biodiversity is a combination of two words, *Bio* (life) and *diversity* (variety).

Biodiversity is formally defined by the Convention on Biological Diversity (CBD) as: "the variability among living organisms from all sources including, among others, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".

In simple terms, biodiversity is the number and variety of organisms found within a specified geographic region. It refers to the varieties of plants, animals and micro-organisms, the genes they contain and the ecosystems they form. It relates to the variability among living organisms on the earth, including the variability within and between the species and that within and between the ecosystems.

- According to the IUCN (2004), the total number of plant and animal species described so far is slightly more than 1.5 million, but there is no clear idea of how many species are yet to be discovered and described.
- Some extreme estimates range from 20 to 50 million, but a more conservative and scientifically sound estimate made by Robert May places the global species diversity at about 7 million.

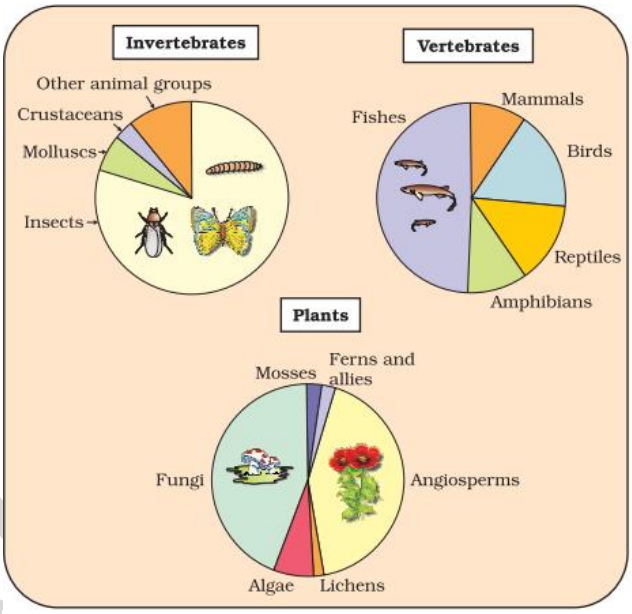
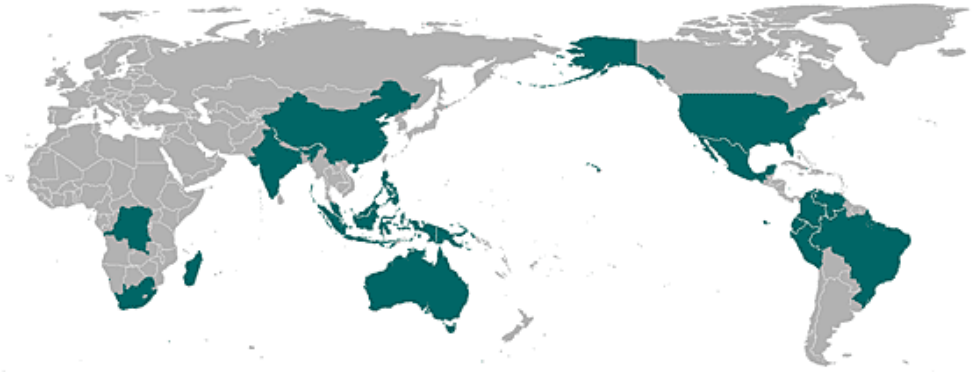


Figure 1: Representing global biodiversity: proportionate number of species of major taxa of plants, invertebrates and vertebrates

2.1.1. BIODIVERSITY OF INDIA

- With only 2.4% of the world's land area, its share of the global species diversity is an impressive 8.1 per cent
- This includes 45,500 recorded species of plants and 91,000 recorded species of animals.
- There is diversity of ecological habitats like forests, grassland, wetlands, coastal and marine ecosystems, and desert ecosystems.
- India is considered one of the world's 17 "megadiverse" countries in terms of biodiversity.
- India has four global biodiversity hot spots (Eastern Himalaya, Indo-Burma, Western Ghats and Sri Lanka, and Sundaland).



Mega-diverse countries:

The megadiverse countries are a group of countries that harbor the majority of the Earth's species and are therefore considered extremely biodiverse. Conservation International identified 17 megadiverse countries in 1998. Together, these 17 countries harbour more than 70% of the earth's species. All megadiverse countries are located in, or partially in, tropical or subtropical regions. All are located in, or partially in, tropical or subtropical regions.

The identified Megadiverse Countries are: United States of America, Mexico, Colombia, Ecuador, Peru, Venezuela, Brazil, Democratic Republic of Congo, South Africa, Madagascar, India, Malaysia, Indonesia, Philippines, Papua New Guinea, China and Australia.

- The principle criterion is endemism, first at the species level and then at higher taxonomic levels such as genus and family. To qualify as a Megadiverse Country, a country must:
  1. Have at least 5000 of the world's plants as endemics.
  2. Have marine ecosystems within its borders.
- Despite endemism being the main criterion, thresholds for the criteria are flexible and countries have been considered individually based on all criteria.

2.2. LEVELS OF BIODIVERSITY

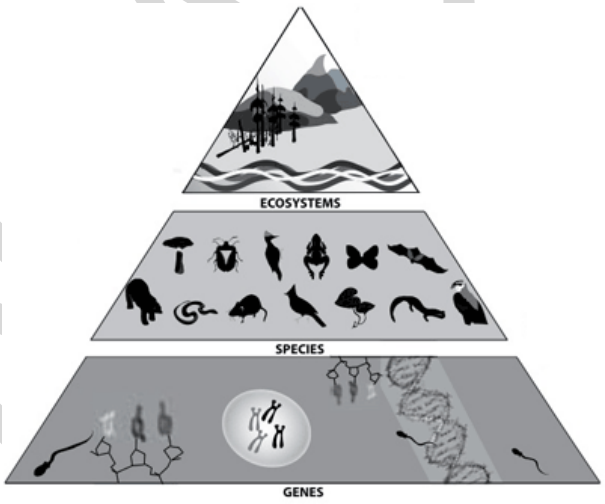
Biodiversity can be discussed at three levels: Genetic diversity, Species diversity and Ecosystem diversity.

2.2.1. GENETIC DIVERSITY

- Genetic biodiversity refers to the variation of genes within species.
- Groups of individual organisms having certain similarities in their physical characteristics are called *species*.
- Human beings genetically belong to the *homo-sapiens* group and also differ in their characteristics such as height, colour, physical appearance, etc., considerably. This is due to genetic diversity.
- The genetic diversity is essential for a healthy breeding of population of species.

2.2.2. SPECIES DIVERSITY

- This refers to the variety of species.
- It relates to the number of species in a defined area.
- The diversity of species can be measured through its *richness, abundance and types*. Some areas are richer in species than others. Areas rich in species diversity are called hotspots of diversity.

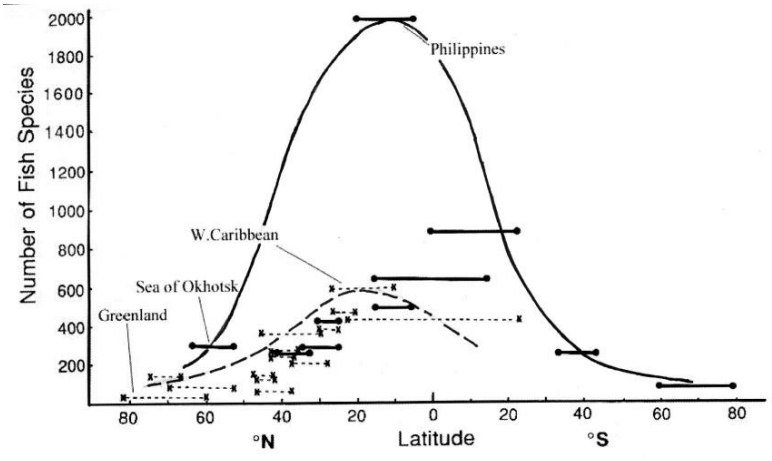


2.2.3. ECOSYSTEM DIVERSITY

- The broad differences between ecosystem types and the diversity of habitats and ecological processes occurring within each ecosystem type constitute the ecosystem diversity.
- The boundaries of communities (associations of species) and ecosystems are not very rigidly defined.
- Thus, the demarcation of ecosystem boundaries is difficult and complex.

2.3. PATTERNS OF BIODIVERSITY

Biodiversity as we have today is the result of 2.5-3.5 billion years of evolution It is consistently richer in the tropics. The distribution of biodiversity can be discussed as under **Latitudinal gradients:** Tropical forests are very rich in bio-diversity. As one approaches the Polar Regions, one finds larger and larger populations of fewer and fewer species. With very few exceptions, tropics (latitudinal range of 23.5° N to 23.5° S) harbour more species than temperate or polar areas.



Forest in a tropical region like Ecuador has up to 10 times as many species of vascular plants as a forest of equal area in a temperate region like the Midwest of the USA. Decline in richness with latitude may be faster in the Northern than in the Southern Hemisphere and the peaks in richness may not lie actually at the Equator itself but some distance away.

Species-Area relationships: Within a region species richness increases with increasing explored area, but only up to a limit. In fact, the relation between species richness and area for a wide variety of taxa (angiosperm plants,

birds, bats, freshwater fishes) turns out to be a rectangular hyperbola. It implies that even if area is increased further the richness of species will tend to become constant.

What is so special about tropics that might account for their greater biological diversity?

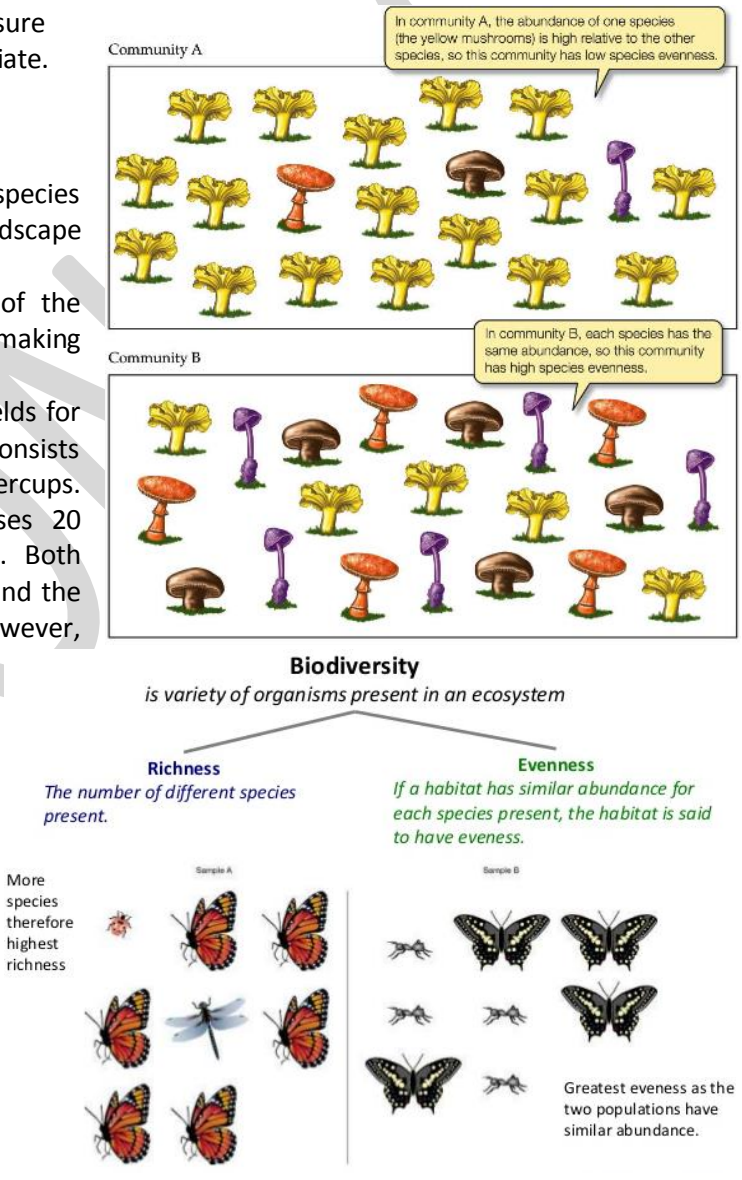
Various hypotheses have been given. Some important ones are:

- **Speciation** is generally a *function of time*, unlike temperate regions subjected to frequent glaciations in the past, tropical latitudes have remained relatively undisturbed for millions of years and thus, had a long evolutionary time for species diversification.
- Tropical environments, unlike temperate ones, are **less seasonal**, relatively more constant and predictable. Such constant environments promote niche specialisation and lead to a greater species diversity.
- There is **more solar energy** available in the tropics, which contributes to higher productivity; this in turn might contribute indirectly to greater diversity.

2.4. MEASUREMENT OF BIODIVERSITY

Scientists use different biodiversity indices to measure diversity, and no single one will always be appropriate. The two main factors taken into account when measuring diversity are richness and evenness.

- **Species richness**: It is the number of different species represented in an ecological community, landscape or region.
- **Species evenness**: Evenness is a measure of the relative abundance of the different species making up the richness of an area.
- For example, there might be two different fields for wildflowers. The sample from the first field consists of 300 daisies, 335 dandelions and 365 buttercups. The sample from the second field comprises 20 daisies, 49 dandelions and 931 buttercups. Both samples have the same richness (3 species) and the same total number of individuals (1000). However, the first sample has more evenness than the second. This is because the total number of individuals in the sample is quite evenly distributed between the three species. In the second sample, most of the individuals are buttercups, with only a few daisies and dandelions present. Sample 2 is therefore considered to be less diverse than sample 1.
- Many diversity indices have been developed that combine different measures of biodiversity. One is called the **Simpson's Index**, which takes into account both species richness, and an evenness of abundance among the species present.
- Diversity may be measured at different scales. These are three indices used by ecologists:
    1. Alpha diversity refers to diversity within a particular area, community or ecosystem, and is measured by counting the number of taxa(usually species) within the ecosystem.
    2. Beta diversity is species diversity between ecosystems; this involves comparing the number of taxa that are unique to each of the ecosystems.
    3. Gamma diversity is a measurement of the overall diversity for different ecosystems within a region.



Species richness and evenness in measurement of biodiversity

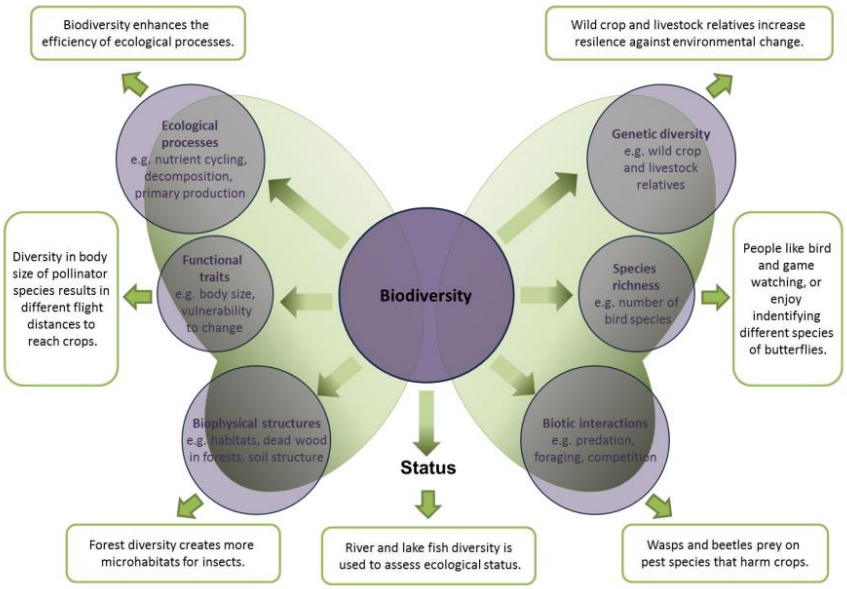
The more diverse an ecosystem, better are the chances for the species to survive through adversities and attacks, and consequently, is more productive. Hence, the loss of species would decrease the ability of the system to maintain itself. Just like a species with a high genetic diversity, an ecosystem with high biodiversity may have a greater chance of adapting to environmental change. In other words, the more the variety of species in an ecosystem, the more stable the ecosystem is likely to be.

2.5. IMPORTANCE OF BIODIVERSITY

Biodiversity has contributed in many ways to the development of human culture and, in turn, human communities have played a major role in shaping the diversity of nature at the genetic, species and ecological levels. Biodiversity plays the following roles:

2.5.1. ECOLOGICAL ROLES

- Species of many kinds perform some or the other functions in an ecosystem. Every organism, besides extracting its needs, also contributes something useful to other organisms.
- Species capture and store energy, produce and decompose organic materials, help to cycle water and nutrients throughout the ecosystem, fix atmospheric gases and help regulate the climate.
- Thus, they help in soil formation, reducing pollution, protection of land, water and air resources.
- These functions are important for ecosystem function and human survival.



Various services provided by biodiversity

2.5.2. ECONOMIC ROLE

Biodiversity is an important resource in day-to-day life. One important part of biodiversity is 'crop diversity', which is also called **agro-biodiversity**. Biodiversity is seen as a reservoir of resources to be drawn upon for the manufacture of food, pharmaceutical, and cosmetic products. This concept of biological resources is responsible for the deterioration of biodiversity. Some of the important economic commodities that biodiversity supplies to humankind are: food crops, livestock, forests, fish, medicinal resources, etc.

2.5.3. SCIENTIFIC ROLE

Biodiversity is important because each species can give us some clue as to how life evolved and will continue to evolve. Biodiversity also helps in understanding how life functions and the role of each species in sustaining ecosystems of which we are also a species.

2.5.4. SOCIAL/CULTURAL SERVICES

Diversity of nature provides us aesthetic pleasure. It provides us recreational avenues and rich biological diversity encourages tourism in the region. Many communities and cultures have co-evolved with the surroundings and the resources provided by a biologically diverse environment. Hence, it performs an important social role as well. Important services which it provides are:

- Recreation and Relaxation
- Tourism especially eco-tourism
- Art, Design and Inspiration
- Spiritual experiences and a sense of place

It is our ethical responsibility to consider that each and every species along with us have an intrinsic right to exist. Hence, it is morally wrong to voluntarily cause the extinction of any species. The level of biodiversity is a good indicator of the state of our relationships with other living species.

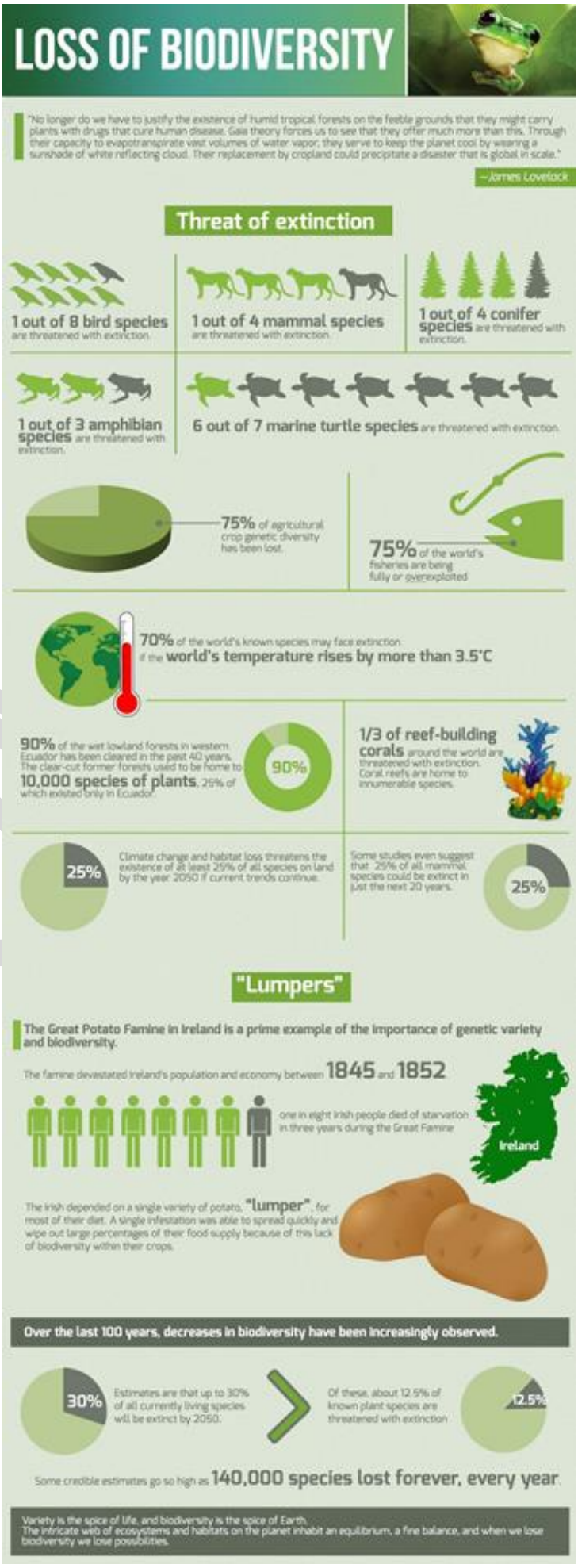
2.6. LOSS OF BIODIVERSITY

The biological wealth of the planet has been declining rapidly.

- The colonisation of tropical Pacific Islands by humans is said to have led to the extinction of more than 2,000 species of native birds.
- The IUCN Red List (2004) documents the extinction of 784 species (including 338 vertebrates, 359 invertebrates and 87 plants) in the last 500 years.
- Some examples of recent extinctions include the dodo (Mauritius), quagga (Africa), thylacine (Australia), Steller's Sea Cow (Russia) and three subspecies (Bali, Javan, Caspian) of tiger.
- The last twenty years alone have witnessed the disappearance of 27 species.

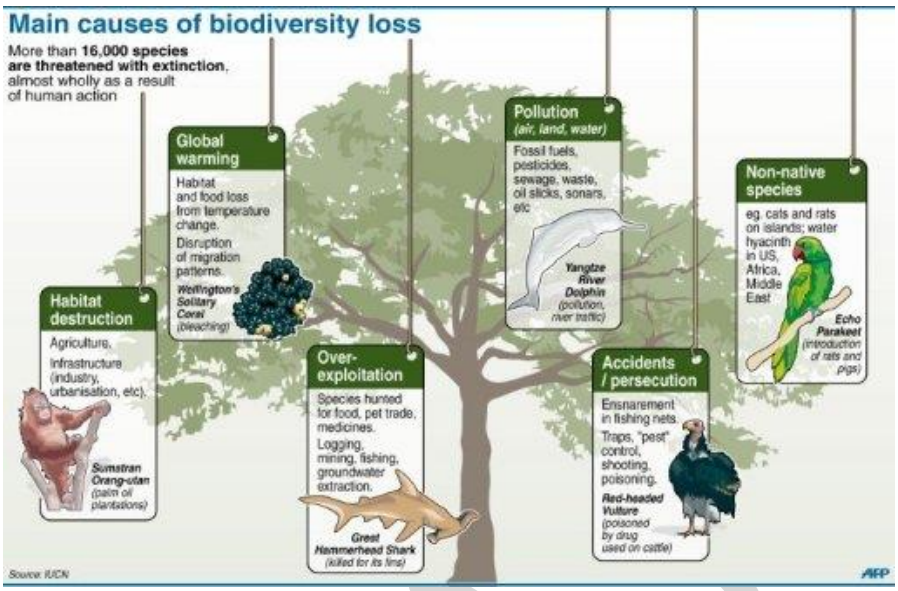
2.6.1. CAUSES OF BIODIVERSITY LOSSES

1. **Natural causes** like floods, earthquakes and other natural disasters.
2. **Habitat loss and fragmentation**:
   - This is the most important cause driving animals and plants to extinction. The most dramatic examples of habitat loss come from tropical rain forests. Once covering more than 14 per cent of the earth's land surface, these rain forests now cover no more than 6 per cent.
   - Besides total loss, the degradation of many habitats by pollution also threatens the survival of many species. When large habitats are broken up into small fragments due to various human activities, mammals and birds requiring large territories and certain animals with migratory habits are badly affected, leading to decline of population.
   - Habitat loss is caused by deforestation, over-population, pollution, global warming etc.
3. **Over-exploitation:** Over-hunting, over-fishing or over-collecting of a species can quickly lead to its decline. Changing consumption patterns of humans is often cited as the key reason for this unsustainable exploitation of natural



resources. Many species extinctions in the last 500 years (Steller's sea cow, passenger pigeon) were due to overexploitation by humans.

4. **Alien species invasions**: When alien species are introduced unintentionally or deliberately for any purpose, some of them turn invasive, and cause decline or extinction of indigenous species.
5. **Co-extinctions**: When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct. When a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate.



Main causes of biodiversity loss

6. **Global climate change**: Both climate variability and climate change cause biodiversity loss. Species and populations may be lost permanently, if they are not provided with enough time to adapt to changing climatic conditions.
7. **Hunting and Poaching:** Because of this, not only the particular species become prone to extinction but also the other species dependent on that species.

2.6.2. EXTINCTION EVENT

Extinction is every day. Mass extinction is not. An extinction event (or mass extinction) is a widespread and rapid decrease in biodiversity of earth. It occurs when the prevailing rate of extinction far exceeds the background or natural rate of extinction. This rate is measured normally in number of species going extinct over a given period of time. The opposite of extinction is speciation- the rate at which new species are formed, which contributes to the biodiversity. There is little evidence of a total decline in biodiversity in recent or pre-human history. In fact, the total number of species on earth has been steadily increasing. This implies average speciation rates are similar to or higher than average extinction rates. In fact, extinction events are important starting point of speciation activities as new and dormant species flourish due to wiping out of competition. Domination and spread of Dinosaurs during Jurassic period is considered as a consequence of Permian extinction event.

More than 90% of all organisms that have ever lived on Earth are extinct. As new species evolve to fit ever changing ecological niches, older species fade away. But the rate of extinction is far from constant. Extinction events are recorded through mass disappearance of fossil records, especially for marine organisms, whose fossils are better preserved. Scientists have recognised several mass extinction events in past 500 million years, out of which five are considered to the major ones. These are:

1. **End Ordovician-Silurian EE (450-440 million years):** During the Ordovician, most life was in the sea, so it was sea creatures such as trilobites, brachiopods and graptolites that were drastically reduced in number.

2. Late Devonian EE (375 my): Trilobites were the most diverse and abundant species. They were almost wiped out in this phase. The likely culprit was the newly evolved land plants that emerged, covering the planet during the Devonian period. Their deep roots stirred up the earth, releasing nutrients into the ocean. This might have triggered algal blooms which sucked oxygen out of the water, suffocating bottom dwellers like the trilobites.

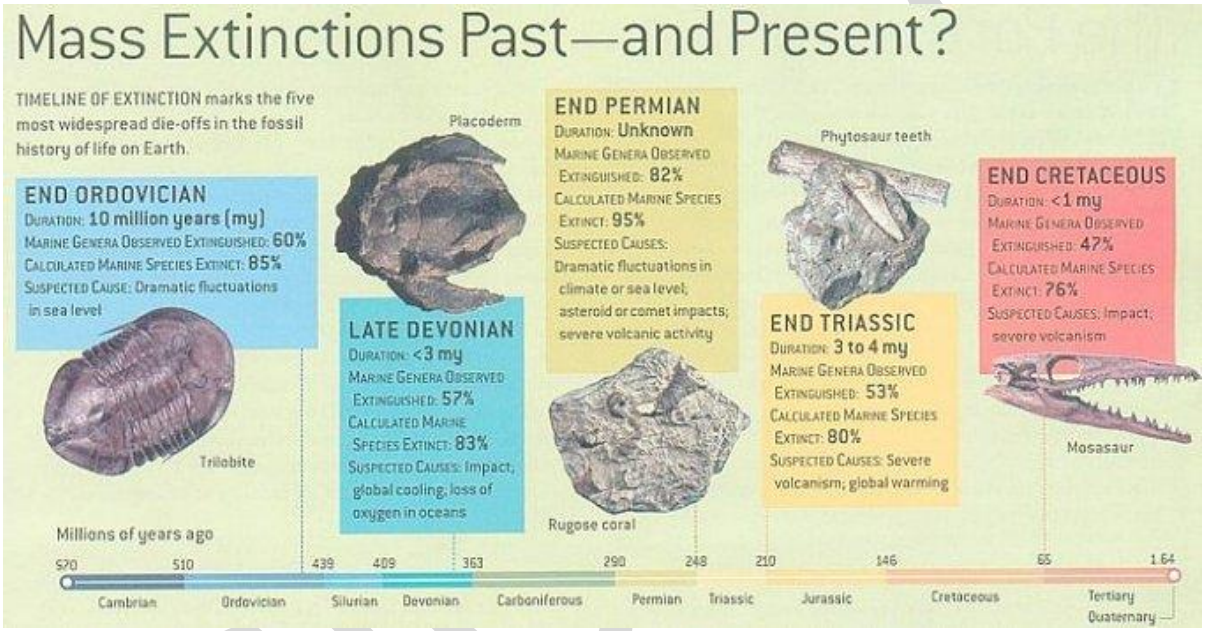
3. Permian-Triassic EE (250 my): The Permian mass extinction has been nicknamed The Great Dying, since a staggering 96% of species died out. All life on Earth today is descended from the 4% of species that survived. A cataclysmic eruption near Siberia blasted CO2 into the atmosphere. Methanogenic bacteria responded by belching out methane, a potent greenhouse gas. Global temperatures surged while oceans acidified and stagnated, belching poisonous hydrogen sulfide. Rocks after this period record no coral reefs or coal deposits.

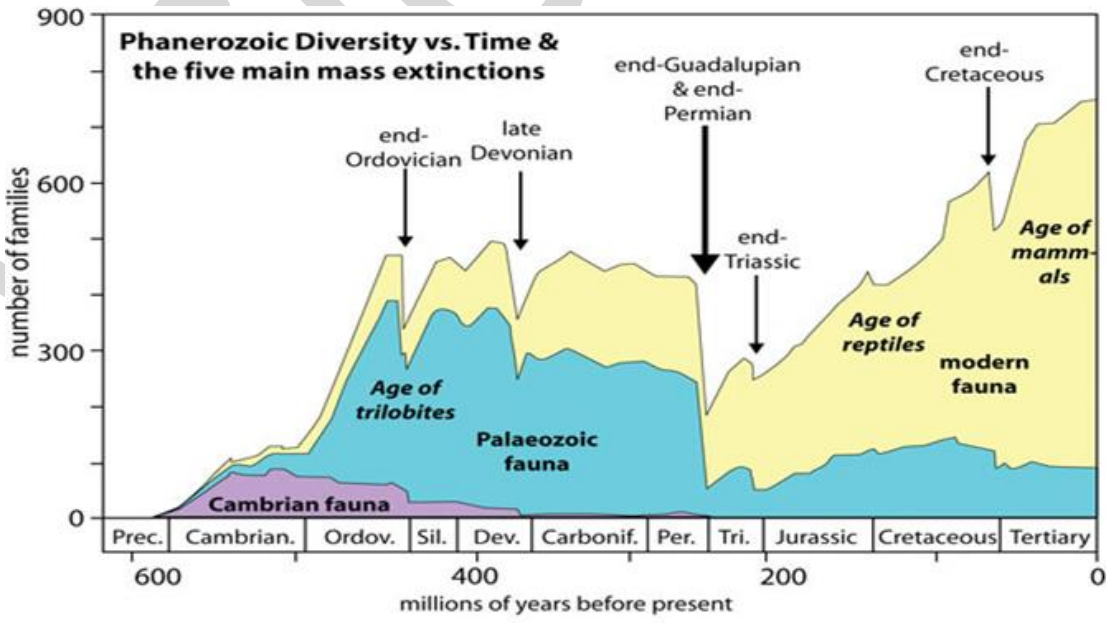
4. Triassic-Jurassic EE (200 my): Estimated 80% species were lost during this phase. No definite cause has been found. Climate change, flood basalt eruptions and an asteroid impact have all been blamed for this loss of life.

5. Cretaceous-Tertiary EE (66 my): The Cretaceous-Tertiary mass extinction - also known as the K/T extinction - is famed for the death of the dinosaurs. However, many other organisms perished at the end of the Cretaceous including the ammonites (which were most abundant marine organisms), many flowering plants and the last of the pterosaurs.

General Causes of mass extinctions of past:

- Change in chemical composition of atmosphere and hydrosphere (such as loss of oxygen)
- Flood basalt events (volcanic eruptions) and releasing of trapped gases
- Temperature changes- global warming or cooling
- Cosmic factors such as asteroid impact
- Sea level change
- Asteroid impact or volcanism lead to debris in atmosphere, which blocks sunlight for long duration
- During this period, greenhouse gases such as methane also collect in atmosphere – as soon as debris clears, there is fast paced rise in temperature.





Present Mass Extinction phase

It is estimated that the extinction rate today is at least 100 times the background or natural rate. Scientists believe that we have entered the age of sixth mass extinction, caused almost entirely due to anthropogenic activities. According to studies, about 300 terrestrial vertebrates have gone extinct in the past 500 years and

about 16-33% of all species are either endangered or threatened. Most vulnerable to extinction today are amphibians (41% of all amphibians, 26% of mammals and 13% of birds face extinction).

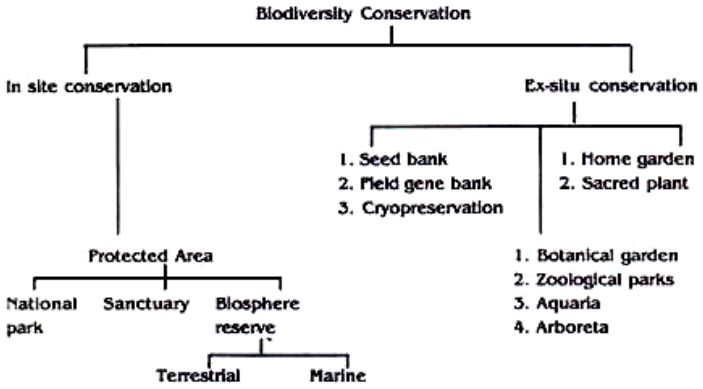
Modern causes of extinction:

- Land development and habitat destruction
- Invasive species
- Anthropogenic emissions into land and water

2.7. BIODIVERSITY CONSERVATION

Biodiversity is important for human existence. All forms of life are so closely interlinked that disturbance in one gives rise to imbalance in the others. If species of plants and animals become endangered, they cause degradation in the environment, which may threaten human being's own existence.

There are two approaches in biodiversity conservation:



1. **In situ conservation**: It is the approach of protecting
   an endangered plant or animal species in its natural habitat, either by protecting or cleaning up the habitat itself, or by defending the species from predators. Some methods under it are:
   - Biosphere Reserves
   - National Parks
   - Wild-life Sanctuaries
2. **Ex-situ conservation**: In this approach, threatened animals and plants are taken out from their natural habitat and placed in special setting where they can be protected and given special care.

Zoological parks, botanical gardens and wildlife safari parks serve this purpose.

In recent years ex situ conservation has advanced beyond keeping threatened species in enclosures.

Now gametes of threatened species can be preserved in viable and fertile condition for long periods using cryopreservation techniques, eggs can be fertilised in vitro, and plants can be propagated using tissue culture methods.

Seeds of different genetic strains of commercially important plants can be kept for long periods in seed banks.

There is an increasing consciousness of the fact that such conservation with sustainable use is possible only with the involvement and cooperation of local communities and individuals. For this, the development of institutional structures at local levels is necessary. The critical issue is not merely the conservation of species nor the habitat but the continuation of process of conservation. The **world conservation strategy**[1] has suggested the following steps for biodiversity conservation:

1. Efforts should be made to preserve the species that are endangered.
2. Prevention of extinction requires proper planning and management.
3. Varieties of food crops, forage plants, timber trees, livestock, animals and their wild relatives should be preserved;
4. Each country should identify habitats of wild relatives and ensure their protection.
5. Habitats where species feed, breed, rest and nurse their young should be safeguarded and protected.
6. International trade in wild plants and animals should be regulated.

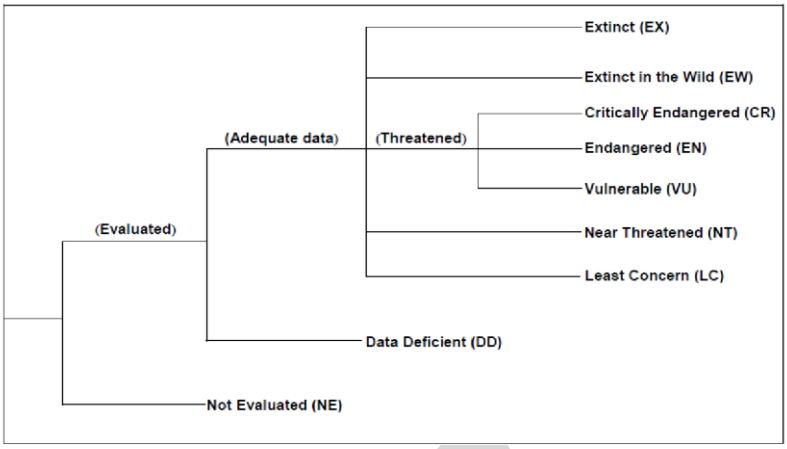
Conservation status

The International Union of Conservation of Nature and Natural Resources (IUCN) has classified the species of plants and animals into various categories for the purpose of their conservation which are as follows:

[1] It was one of the seminal documents by IUCN which served to redefine environmentalism. Launched in 1980 by IUCN, the strategy recognized that addressing environmental problems calls for long-term effort and the integration of environmental and development objectives.

The A to E criteria are:

- Declining population (past, present and/or projected)
- Geographic range size, and fragmentation, decline or fluctuations
- Small population size and fragmentation, decline, or fluctuations
- Very small population or very restricted distribution
- Quantitative analysis of extinction risk (e.g., Population Viability Analysis)



IUCN Red List Categories

EXTINCT (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EXTINCT IN THE WILD (EW)

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range.

CRITICALLY ENDANGERED (CR)

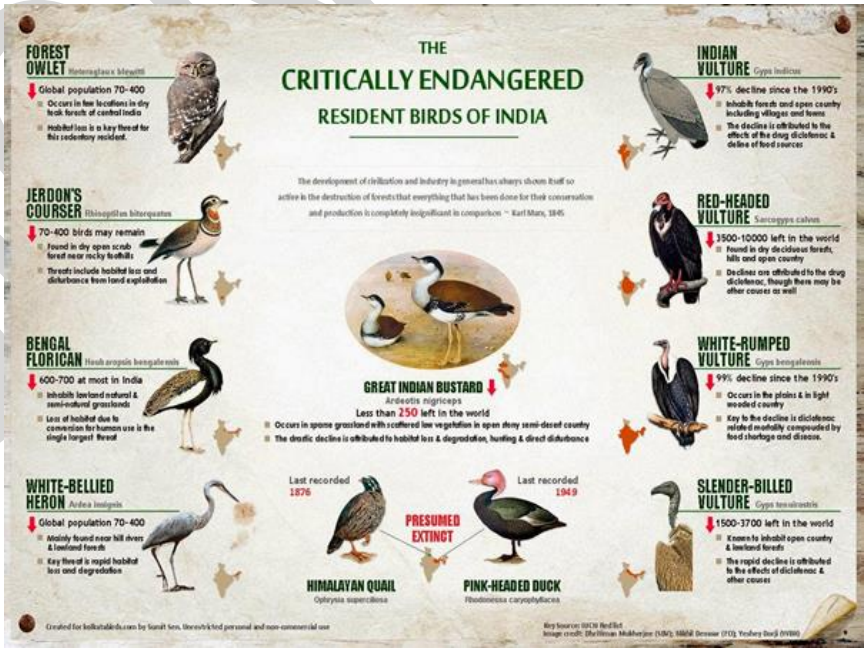
A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an **extremely high** risk of extinction in the wild.

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a **very high** risk of extinction in the wild.

VULNERABLE (VU)

A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a **high** risk of extinction in the wild.



NEAR THREATENED (NT)

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC)

A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD)

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status.

NOT EVALUATED (NE)

A taxon is Not Evaluated when it has not yet been evaluated against the criteria.

2.8. BIODIVERSITY HOTSPOT

The concept of biodiversity hotspots was given by Norman Myers. A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is threatened with destruction. These hot spots which cover less than 2% of the world's land area are found to have about 50% of the terrestrial biodiversity. Criteria for determining hot-spots:

- Contain at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics (species found nowhere else on Earth).
- Degree of threat, which is measured in terms of Habitat loss: Have lost at least 70 percent of its original habitat.

There are 35 such hot spots of biodiversity on a global level.

Plants: The hotspots hold at least 150,000 endemic plant species, 50 percent of the world's total vascular plants.

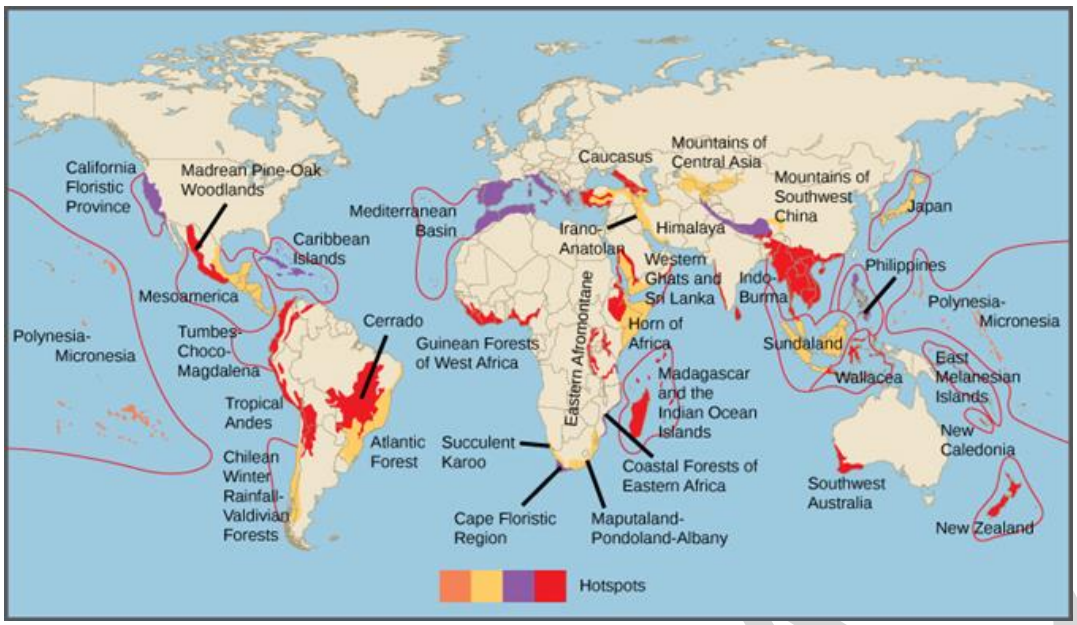
Vertebrates: Overall, 11,980 mammals, birds, reptiles and amphibians are endemic to the hotspots (42 percent of all terrestrial vertebrates), while a total of 22,022 vertebrate species occur in the hotpots (77 percent of the world's total). In addition, there are more than 3,400 freshwater fish species endemic to the hotspots, which is likely to be an underestimate.

Vegetation: The biodiversity hotspots once stretched across 15.7 percent of the Earth's land surface, however 86 percent of the hotspots' original habitat has already been destroyed. Today, the intact remnants of the hotspots now cover only 2.3 percent of the Earth's land surface.

I. Africa 1. Cape Floristic Region 2. Coastal Forests of Eastern Africa 3. Eastern Afromontane 4. Guinean Forests of West Africa 5. Horn of Africa 6. Madagascar and the Indian Ocean Islands 7. Maputaland-Pondoland-Albany 8. Succulent Karoo **II. Asia-Pacific** 9. East Melanesian Islands 10. Himalaya 11. Indo-Burma 12. Japan 13. Mountains of Southwest China 14. New Caledonia 15. New Zealand 16. Philippines 17. Polynesia-Micronesia 18. Southwest Australia 19. Forests of Eastern Australia (new) 20. Sundaland 21. Wallacea 22. Western Ghats and Sri Lanka	**III. Europe and Central Asia** 23. Caucasus 24. Irano-Anatolian 25. Mediterranean Basin 26. Mountains of Central Asia **IV. North and Central America** 27. California Floristic Province 28. Caribbean Islands 29. Madrean Pine-Oak Woodlands 30. Mesoamerica **V. South America** 31. Atlantic Forest 32. Cerrado 33. Chilean Winter Rainfall-Valdivian Forests 34. Tumbes-Chocó-Magdalena 35. Tropical Andes

Out of these, four are present in India. These are:

1. **Himalaya:** Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar)
2. **Indo-Burma:** Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China)
3. **Sundalands:** Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)
4. **Western Ghats and Sri Lanka:** Includes entire Western Ghats (and Sri Lanka)



Conservation International's ranking of the world's 10 most threatened forested hotspots, listed by percentage of remaining original habitat:

S. N.	Hotspot	Remaining habitat
1	Indo-Burma (southern Asia)	5%
2	New Caledonia (Pacific Islands)	5%
3	Sundaland (Indonesia/Malaysia)	7%
4	Philippines	7%
5	Atlantic Forest (South America)	8%
6	Mountains of Southwest China	8%
7	California Floristic Province(U.S. and Mexico)	10%
8	Coastal Forests of Eastern Africa	10%
9	Madagascar & Indian Ocean Islands	10%
10	Eastern Afromontane (Africa)	11%

2.9. UPSC QUESTIONS RELATED TO ABOVE TOPICS

1. What is biodiversity? Why should it be preserved? (UPSC 1992/40 Marks)

2. What do you understand by Ecological Balance? Why is this balance necessary? What is being done in India today to maintain this balance? (UPSC 1987/15 Marks)

3. Deforestation contributes to the accumulation of carbon dioxide in the atmosphere in different ways. What are these processes? Explain. (IFS 2011/10 Marks)

4. What is biodiversity? How have human activities in recent decades affected biodiversity? (IFS 2012/10 Marks).

2.10. PRELIMS QUESTIONS

1. Due to improper/indiscriminate disposal of hold and used computers or their parts, which of the following are released into the environment as e-waste? (2013)

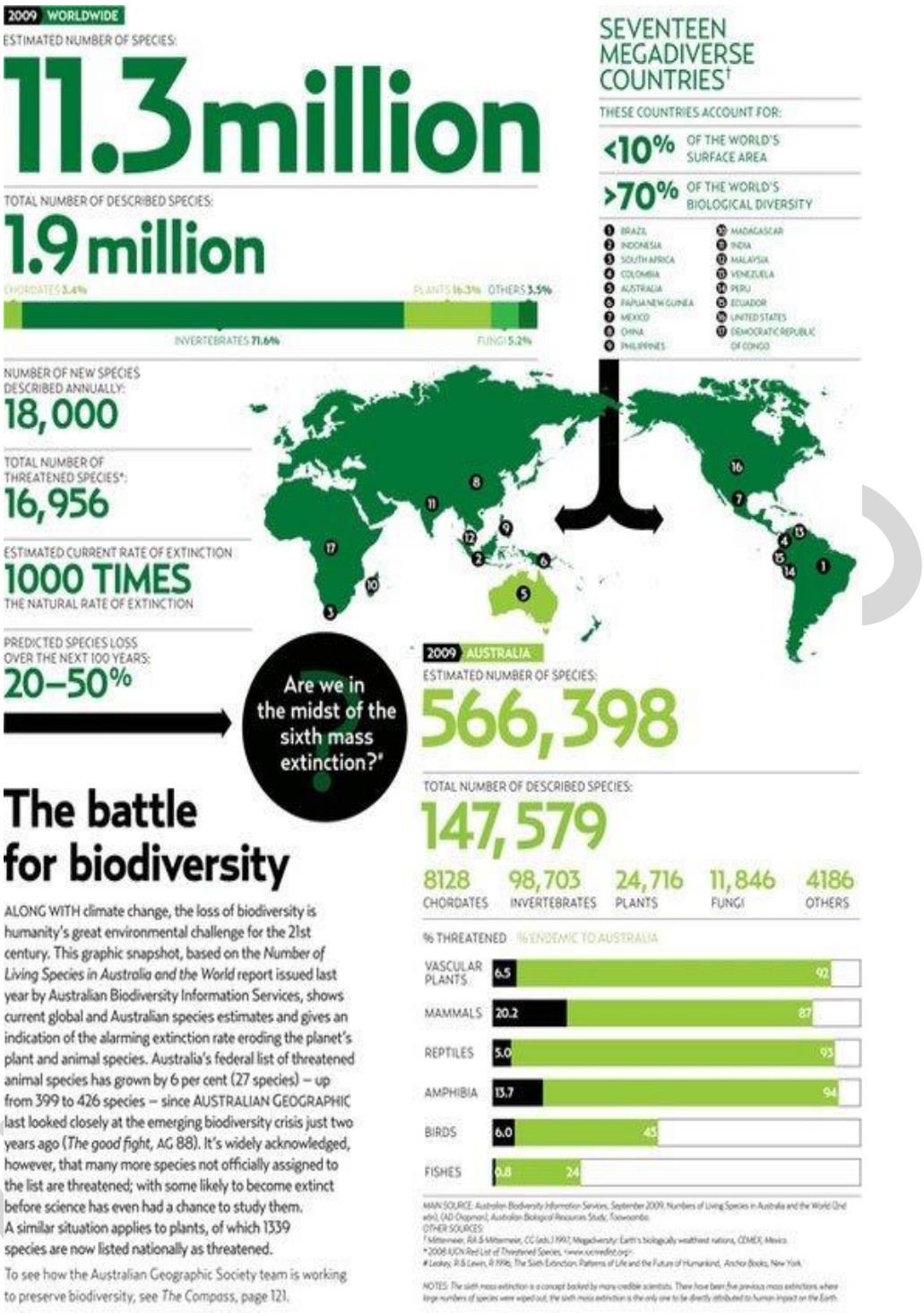
1. Beryllium
2. Cadmium
3. Chromium
4. Heptachlor
5. Mercury
6. Lead
7. Plutonium

Select the correct answer using the codes given below:

(a) 1, 3, 4, 6 and 7 only (b) 1, 2, 3, 5 and 6 only

(c) 2, 4, 5 and 7 only (d) 1, 2, 3, 4, 5, 6 and 7

Correct Answer: (b)



2. Improper handling and storage of cereal grains and oilseeds result in the production of toxins known as aflatoxins which are not generally destroyed by normal cooking process. Aflatoxins are produced by:(2013)

(a) bacteria (b) protozoa (c) moulds (d) viruses

Correct Answer: (c)

3. Which of the following can be threats to the biodiversity of a geographical area? (2012)

1. Global warming
2. Fragmentation of habitat
3. Invasion of alien species
4. Promotion of vegetarianism

Select the correct answer using the codes given below:

(a) 1, 2 and 3 only (b) 2 and 3 only (c) 1 and 4 only (d) 1, 2, 3 and 4

Correct Answer: (d)

4. Consider the following statements: (2012)
Chlorofluorocarbons, known as ozone-depleting substances, are used
1. In the production of plastic foams.
2. In the production of tubeless tyres.
3. In cleaning certain electronic components.
4. As pressurizing agents in aerosol cans.

Which of the statements given above is/are correct?
(a) 1, 2 and 3 only (b) 4 only (c) 1, 3 and 4 only (d) 1, 2, 3 and 4
Correct Answer: (c)

5. Biodiversity forms the basis for human existence in the following ways: (2011)
1. Soil formation
2. Prevention of soil erosion
3. Recycling of waste
4. Pollination of crops

Select the correct answer using the codes given below:
(a) 1, 2 and 3 only (b) 2, 3 and 4 only (c) 1 and 4 only (d) 1, 2 3 and 4
Correct Answer: (d)

6. Three of the following criteria have contributed to the recognition of Western Ghats-Sri Lanka and Indo-Burma regions as hotspots of biodiversity: (2011)
1. Species richness
2. Vegetation density
3. Endemism
4. Ethno-botanical importance
5. Threat perception
6. Adaptation of flora and fauna to warm and humid conditions

Which three of the above are correct criteria in this context?
(a) 1 2 and 6 (b) 2, 4 and 6 (c) 1, 3 and 5 (d) 3, 4 and 6
Correct Answer: (c)

7. Which one of the following is not a site for in-situ method of conservation of flora? (2011)
(a) Biosphere Reserve (b) Botanical Garden (c) National Park (d) Wildlife Sanctuary
Correct Answer: (b)

8. Consider the following statements: (2011)
1. Biodiversity is normally greater in the lower latitudes as compared to the higher latitudes.
2. Along the mountain gradients, biodiversity is normally greater in the lower altitudes as compared to the higher altitudes.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only (c) Both 1 and 2 (d) Neither 1 nor 2
Correct Answer: (c)

9. In which one among the following categories of protected areas in India are local people not allowed to collect and use the biomass? (2012)
(a) Biosphere Reserves (b) National Parks
(c) Wetlands declared under Ramsar Convention (d) Wildlife Sanctuaries
Correct Answer: (b)

10. Sustainable development is described as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In this perspective, inherently the concept of sustainable development is intertwined with which of the following concepts? (2010)
(a) Social justice and empowerment (b) Inclusive Growth
(c) Globalization (d) Carrying capacity
Correct Answer: (d)
Explanation: The carrying capacity of a biological species in environment is the population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment. For the human population, more complex variables such as

sanitation and medical care are sometimes considered as part of the necessary establishment. Thus Sustainable development is intertwined with Carrying capacity.

11. Consider the following regions: (2009)
1. Eastern Himalayas
2. Eastern Mediterranean region
3. North-western Australia

Which of the above is/are Biodiversity Hotspot(s)?
(a) 1 only (b) 1 and 2 only (c) 2 and 3 only (d) 1, 2 and 3
Correct Answer: (b)

12. Consider the following statements regarding environmental issues of India: (2001)
1. Gulf of Mannar is one of the biosphere reserves.
2. The Ganga Action Plan, phase II has been merged with the National River Conservation Plan.
3. The National Museum of Natural History at New Delhi imparts non-formal education in environment and conservation.
4. Environmental Information System (ENVIS) acts as a decentralized information network for environmental information.

Which of these statements are correct?
(a) 1, 2 and 4 (b) 1, 2, 3 and 4 (c) 2 and 3 (d) 1, 3 and 4
Correct Answer: (b)

PLANT COMMUNITIES AND MAJOR VEGETATION

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3. PLANT COMMUNITIES AND MAJOR VEGETATION

3.1. PLANT COMMUNITY

A group of populations of different species living in the same local areas and interacting with one another is called ecological community. So, the group or association of plants growing together in a particular habitat is called plant community.

The plant community of a given habitat consists of two or more different species. It has two basic characteristics

1. Plants are ecologically related and can live and grow together in a particular habitat, and
2. The Plant community is well organised i.e., it has well developed composition and structure which is the result of continuous interactions between the different species and with their environment.

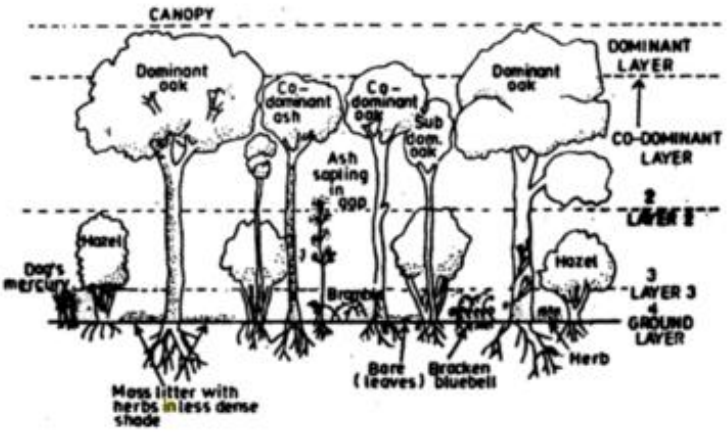
3.2. VEGETATION

Vegetation is assemblages of plant species and the ground cover they provide. It is a general term, without specific reference to particular taxa, life forms, structure, spatial extent, or any other specific botanical or geographic characteristics. It is broader than the term flora which refers to species composition. In other words, all the plants which grow together in any area form its vegetation, the character of which depends not just on the different species present but on the relative proportions in which their members are represented. It is by far the most abundant biotic element of the biosphere.

- Two habitats may have similar floras but their vegetation may vary from one another and two habitats having different floras may have similar vegetation.
- For instance, if there are two similar habitats wherein both have grasses and sal trees but there is overwhelming dominance of grasses and sparse distribution of sal trees in the first habitat whereas the second habitat is characterized by dense sal trees and sparse distribution of grasses, the vegetation of the first habitat will be grasses whereas the vegetation of the second habitat will be sal forest.

3.2.1. VERTICAL STRATIFICATION OF PLANT COMMUNITIES

- The development of different species of plant community of a given region takes place through the processes of adaptation, competition and natural selection.
- Different species of plants are evolved in a habitat having favourable environmental conditions wherein different species of plant community grow together having different life-forms. This results in the development of various strata or layers between the soil surface or ground surface and the tree canopy.
- This vertical layering pattern or vertical stratification of plants is the result of competition among various species of plant community to get sunlight.
- On an average, there are four vertical strata of plant community in a given region mainly in the deciduous forests of the temperate regions-
    1. Dominant layer represents the topmost layer of the plant community which is determined by the canopy of the largest trees. This uppermost stratum is also called crown or canopy which represents the highest limit of plant community in a given region. A secondary layer very often called as co-dominant layer is formed just below the crown or dominant layer by those large trees which are relatively shorter than the largest trees.



    2. Second layer is located below the dominant or crown layer and is represented by plants of shrub by life-form. This is also called as shrub layer.

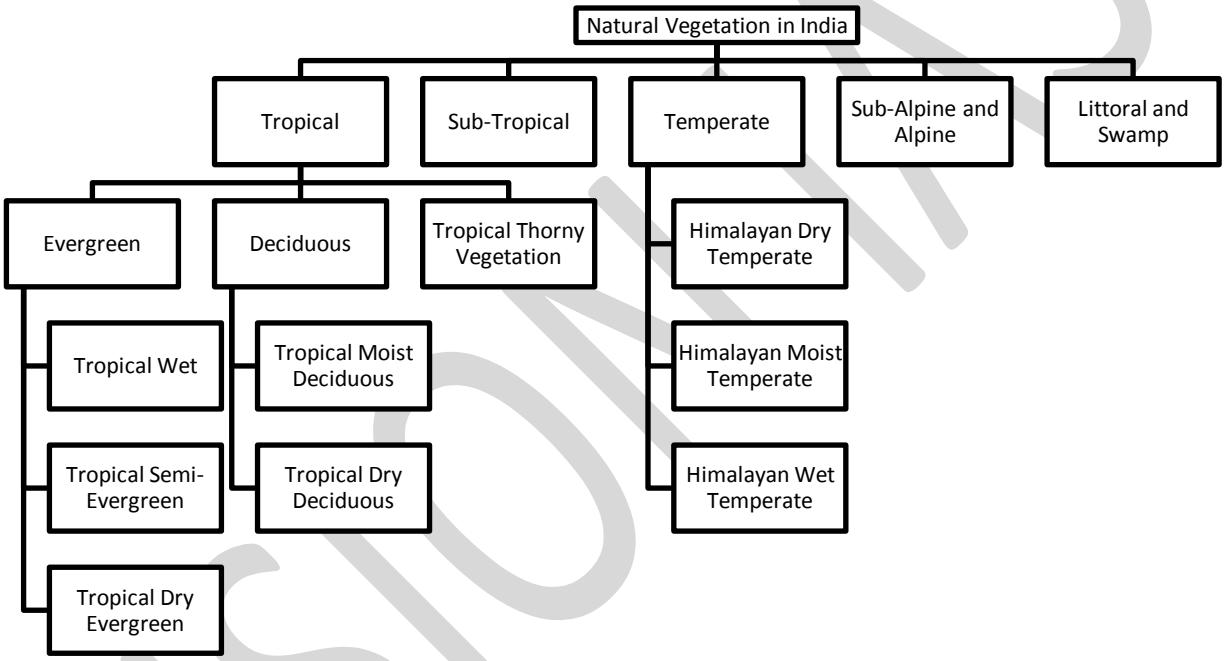
3. Third layer is formed by the herbaceous plants and is also called as herb layer.
4. Fourth layer represents mosses on the ground surface and is also called as moss, layer or ground layer.

3.3. NATURAL VEGETATION IN INDIA

Vegetation type is primarily dependent upon the rainfall and temperature of a place. Other factors like soil type, topography, presence of rivers and mountains, primitive vegetation, animal species etc. also influence the type of vegetation in an area. It adapts to the constraints of natural environment in size, structure and requirements.

The natural vegetation in India ranges from the one that is found in the tropical region to that found in the Arctic region. On the basis of certain common features such as predominant vegetation type and climatic regions, Indian forests can be divided into the following groups: (Total 12 Types by Forest Survey)

1. Tropical Forests – 6 types
2. Subtropical forests – 1 type, can be further divided into 3 classes
3. Temperate – 3 types
4. Alpine – 1 type
5. Littoral and swamp vegetation



1. Tropical Evergreen

Conditions for growth:

Tropical Evergreen and Semi Evergreen Forests are found mainly in the areas where the annual rainfall is more than 250 cm, with a short dry season. The average annual temperature should be above 22 °C.

Characteristics: Lofty, very dense, multi-layered forest with mesophytic evergreen, 45m or more in height, with large number of species, numerous epiphytes, and few climbers; Due to dense growth of trees, the sunlight cannot reach the ground. Thus, the undergrowth mainly consists of canes, bamboos, ferns, climbers, etc.

Location: The true evergreen forests are mostly found along the western slopes of Western Ghats, in the hills of north-eastern states and in the Andaman and Nicobar Islands.

Trees: Important trees of these forests are rosewood, ebony, mahogany, rubber, cinchona, bamboo, coconut, palms, canes, lianas, etc.

Utility: Not commercially exploitable. However, the timber from the tropical evergreen and semi- evergreen a forest is hard, durable, fine-grained and of high economic value.

2. Tropical Semi-Evergreen

These forests are found along the western coasts, eastern Orissa and upper Assam where annual rainfall is between 200 and 250 cm.

They are c**haracterised by** giant and luxuriantly growing intermixed deciduous and evergreen species of trees and shrubs. The under-growing climbers provide an evergreen character to these forests.

The **important plants** in these forests are the species of white cedar, hollock, kail, etc. Orchids, ferns, some grasses and several other herbs are also common.

These forests are less dense and can be easily exploited.

3. Tropical Dry Evergreen

These forests are found in the areas where rainfall is in plenty but dry season is comparatively longer. The trees are dense, evergreen and short (about 10 to 15 metres high). These forests are found in eastern part of Tamil Nadu.

The common plant species are much the same as in Tropical moist evergreen forests. Species of Maba, Calotropis, Pabatta, Feronia, Canthium, Zizyphus, Randia etc. are most common. Bamboos are absent but grasses are common.

4. Tropical Moist Deciduous

These cover an extensive area of the country receiving sufficiently high rainfall (150 to 200 cm) spread over most of the year. The dry periods are of short duration. Many plants of such forests show leaf-fall in hot summer. It is the representative species of the Monsoon climate.

The forests are found along the wet western side of the Deccan plateau, i.e. Mumbai, N-E Andhra, Gangetic plains, Orissa and in some Himalayan tracts extending from Punjab in west to Assam valley in the east.

Teak, Sal, Sheesham, Hurra, Mahua, Amla, Semul, Kusum, Sandalwood etc. are the main species of these forests. These forests produce some of the most important timbers of India..

5. Tropical Dry Deciduous

These forests are distributed in the areas where annual rainfall is usually low, ranging between 70 and 100 cm, such as, Punjab, U.P., and Bihar, Orissa, M.P. and large part of Indian peninsula.

The largest area of the country's forest land is occupied by Tropical dry deciduous forests. The dry season is long and most of the trees remain leafless during that season.

The forest trees are not dense, 10 to 15 m in height, and undergrowth is abundant. In north, the forests are dominated by sal and in south by teak. Tendu, palas, amaltas, bel, kair, axlewood, etc. are the common trees.

Utility: The tropical deciduous forests are commercially most important as they yield valuable timber and a variety of other forest products. They are commercially most exploited. Large tracts of these forests have been cleared to provide more land for agricultural purposes and have also suffered from severe biotic factors, such as over-cutting, overgrazing, fires, etc.

6. Tropical Thorny Vegetation

These forests occur in the areas where annual rainfall is less than 50 cm; dry season is hot and very long. They are found in South-west Punjab, Rajasthan, Gujarat, MP and UP. The vegetation is open stunted forest, breaking down into xerophytic bush and further to the northwest grading into deserts. Most of the vegetation is confined to areas along seasonal rivers. The land away from the rivers and devoid of irrigation is mostly sandy and devoid of trees. The vegetation is of open type consisting of small trees (8 to 10 m high) and thorny or spiny shrubs of stunted growth. The forests remain leafless for most part of the year and are sometimes called thorn scrub or scrub jungles. There is luxuriant growth of ephemeral herbs and grasses during the rainy season.

Important species found are babool, ber, khejri, date palm, khair, neem, palas, acacia etc. Tussocky grass grows up to height of two metres as undergrowth.

Utility: These trees are important in checking the increasing desertification in north-western India.

7. Sub-Tropical Vegetation

Sub-tropical wet hills forests occur at 1000-1200m altitude. In eastern Himalayas, oak chestnut, ash, birch, pine are common species. In Western Himalayas, Chir is most important, while oak occurs in wetter areas. In drier areas of Kashmir (RF 50-100cm) wild olives are common with a variety of scrub.

8. Himalayan Dry Temperate Vegetation

It is found in the inner dry ranges of western Himalayas where precipitation is below 10cm. It is predominantly a coniferous forest with xerophytic shrubs. Epiphytes and climbers are rare. Important species are chilgoza, deodar, oak, maple, ash, celtis, olives, etc.

9. Himalayan Moist Temperate Vegetation

In the western Himalayas, between 1500-3000m, forests of deodar, spruce, maple, walnut, poplar, cedar, chestnut, birch, oak, etc. occur. These are 30-50m in height and undergrowth is mostly evergreen. Mosses and ferns grow on the trees.

10. Himalayan Wet Temperate Vegetation

In the eastern Himalayas, evergreen wet temperate forests occur between 1800-2700m altitude. Oak, poplar, elm, laurel, maple, birch, magnolina are common species. Rainfall is high, temperature is moderate in summers and winters are cold. Rate of evaporation is not high and trees do not shed their leaves. **Nilgiris, Anamalai and the Palani hills** of south India have this kind of forest above 1500m altitude. The trees are shorter there with abundant undergrowth and epiphytes.

11. Sub-Alpine and Alpine Vegetation

It occurs above 2700m in eastern Himalayas and above 3000m in western Himalayas and extends upto the snowline. It is a dense scruby forest of silver firs, junipers, pine, birch and rhododendrons.

- In the **Himalaya Mountains**, one can notice a succession of natural vegetation belts, as we see in the tropical to the tundra region.
- Between the height of 1000 m and 2000 m, the evergreen broad-leaf trees such as oak and chestnut predominate.
- Between the height of 1500 m and 3000 m, the coniferous trees, such as pine, deodar, silver fir, spruce and cedar are found.
- The coniferous forests cover the southern slopes of Himalayas and parts of northeast India. At higher elevations (about 3600 m above sea level) temperate grasslands are common.
- At attitudes above 3600 m, coniferous forests and grasslands give way to the alpine vegetation. Silver firs, junipers, pines and birches are common varieties of trees.
- Ultimately these forests merge into alpine grasslands, through the shrubs and scrubs.
- The southern slopes of the Himalaya Mountains have denser forests than the north facing areas. This is due to relatively higher precipitation.
- At higher altitudes, mosses and lichens form part of vegetation.

- In the **peninsular India**, the mountain forests are found in the three district areas—the Western Ghats, the Vindhyas and the Nilgiris.
- As they are closer to the tropics, and only 1,500 m above the sea level, vegetation is temperate in the higher regions and subtropical on the lower regions of the Western Ghats, especially in Kerala, Tamil Nadu and Karnataka.
- The temperate forests are called Sholas in the Nilgiris, Annamalai and Palani hills.
- **Utility:** Alpine grasslands are extensively used by the nomadic tribes like the Gujjars and the Bakarwals for grazing livestock.

12. Littoral and Swamp

They can be further divided into (i) Beach forests, (ii) Mangroves, and (iii) Fresh water swamps.

The tidal deltas of Ganga, Mahanadi, Godavari and Krishna are all flush with such evergreen vegetation. The soil is sandy having large amount of lime and salts but poor in nitrogen and other mineral nutrients. Ground water is brackish, water table is only a few metres deep and rainfall varies from 75 cm to 500 cm depending upon the area.

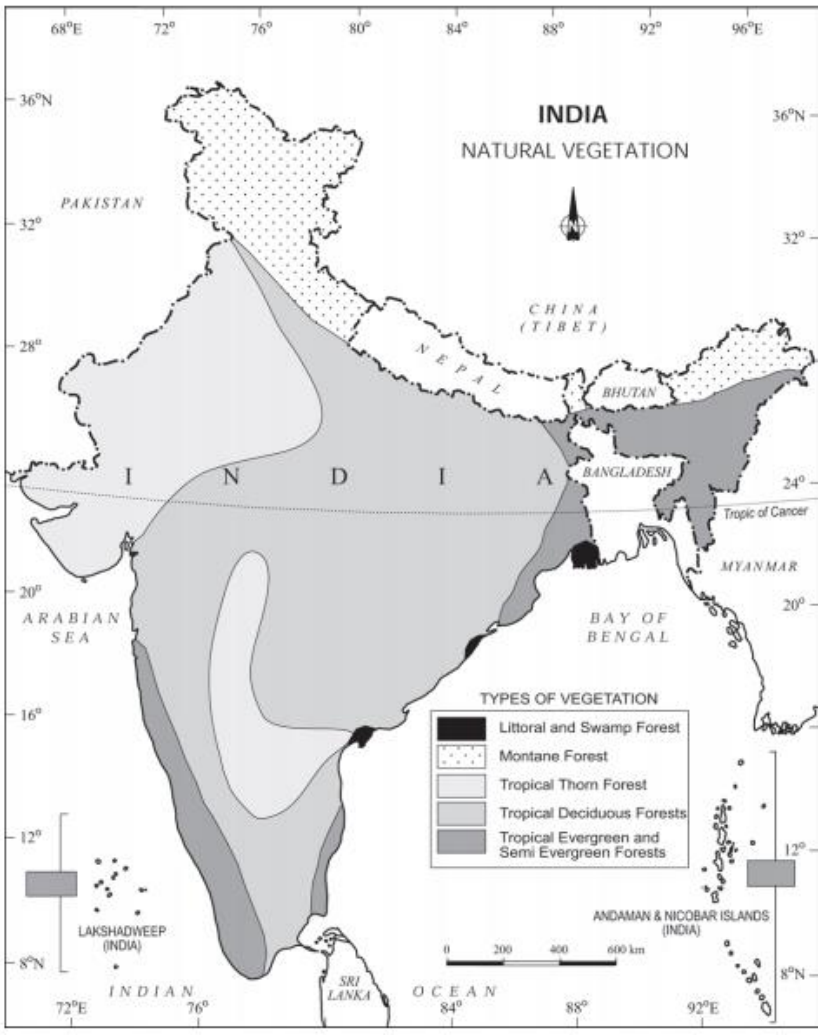
The plants are typical halophytes which are characterised by presence of prop roots with well-developed knees for support and pneumatophores and viviparous germination of seeds. Important species are sundari, bruguiera, sonneratia, agarm bhendi, keora, etc.

Shola Forest

- Sholas are patches of stunted evergreen tropical and sub tropical moist broad leaf forest found in valleys separated by grassland in the higher mountain regions of South India
- The word 'shola' is probably derived from the Tamil language word ‘colai’ meaning grove.
- The shola-forest and grassland complex has been described as a climatic climax vegetation.
- Some of the other trees of this forest of economic significance include magnolia, laurel, cinchona and wattle.
- They are home to a host of endemic and endangered plants and animals.
- They are also vitally important in keeping water cycles alive. They retain most of the rain they get over the monsoons, and release it slowly through the year via a network of streams and rivers that eventually serve the needs of a huge number of human settlements across south India.
- In the recent years exotic species that were planted a few years ago had invaded marshes, shola forests and grasslands.

Important Terms related to vegetation

- **Canopy:** The cover of branches and Foliage formed by the crown of trees is called Canopy.
- **Canopy Density**: The percentage area of land covered by the canopy of trees is called Canopy density.
- **Carbon Stock**: It is defined as the amount of carbon stored in the ecosystem of the forest especially in living biomass and soil.
- **Very Dense Forest**: All lands with tree canopy density of 70% and above.
- **Moderately Dense Forest**: All lands with tree canopy density of 40% and more but less than 70%.
- **Open Forest**: All lands with tree canopy density of 10% and more but less than 40%.
- **Scrub**: Degraded forest land with canopy density less than 10%.
- **Non-Forest**: Lands not included in any of the above classes.
- **Endemic plants:** The original natural vegetation, which are purely native are called the endemic plants.
- **Exotic plants**: Those which have come from outside are called the exotic plants.



3.4. FOREST COVER IN INDIA

The total forest cover of the country, as per India State of Forest Report 2015 is 701,673 sq km which constitutes 21.34 percent of the geographical area of the country. In terms of density classes, area covered by Very Dense Forest (VDF) is 85,904 sq km, that with Moderately Dense Forest (MDF) is 315,374 sq km and Open Forest (OF) is 300,395 sq km. The VDF class constitutes 2.61 percent, the MDF class constitutes 9.59 percent and the OF class constitutes 9.14 percent of total forest cover of the total geographical area of the country.

15 StateS/UTS have above 33 percent of the geographical area under forest cover. Out of these states and UTs, seven states have more than 75 percent forest cover while eight states have forest cover between 33 percent and 75 percent.

3.4.1. INDIA STATE OF FOREST REPORT 2015

- "India State of Forest Report (ISFR)", a biennial report of FSI is published by Forest Survey of India(FSI) since 1987.
- Regular assessment of forest cover is being done by FSI using remote sensing satellite data.
- So far thirteen reports have been published by FSI. The latest report i.e. ISFR 2015 is 14th assessment in this series. The findings are:
- India's forest and tree cover has increased by 5,081 sq km.
- Forest cover of the country as per this assessment is **701,673 sq. km** which is 21.34 percent of the geographical area of the country.
- The tree cover of the country is estimated to be **92,572 sq. km**which is 2.82 percent of the geographical area.
- The total forest and tree cover of the country as per this assessment is **794,245 sq. km** which is 24.16 percent of the geographical area of the country.
- The North Eastern states of India account for one fourth of the country's forest cover.
- Mangroves cover has increase by 112 sq. km as compare to the previous assessment.
- Sunderbans which accounts for half of the total mangrove area in India, has seen a marginal .42% rise in its mangrove cover in the last two years despite several plantation drives taken up by the state there.

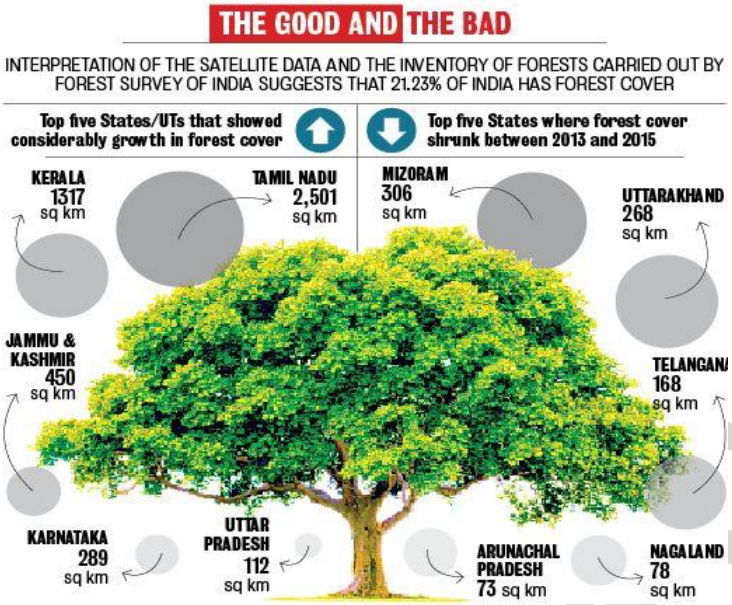
Class	Area (sq km)	percent of Geographical Area
Forest Cover		
Very Dense Forest	85,904	2.61
Moderately Dense Forest	315,374	9.59
Open Forest	300,395	9.14
Total Forest Cover*	701,673	21.34
Scrub	41,362	1.26
Non Forest	2,544,228	77.40
Total Geographic Area	3,287,263	100.00

*Includes 4,740 sq km under mangroves

		2015 Assessment					
States/UTs	Geographical Area	VDF	MDF	OF	Total	Scrub	Forest Cover percent
Mizoram	21,081	138	5,858	12,752	18,748	0	88.93
Lakshadweep	32	0	17.22	9.84	27.06	0	84.56
A&N Islands	8,249	5,686	685	380	6,751	1	81.84
Arunachal Pradesh	83,743	20,804	31,301	15,143	67,248	264	80.30
Nagaland	16,579	1,296	4,695	6,975	12,966	622	78.21
Meghalaya	22,429	449	9,584	7,184	17,217	348	76.76
Manipur	22,327	727	5,925	10,342	16,994	1182	76.11
Tripura	10,486	113	4,609	3,089	7,811	55	74.49
Goa	3,702	542	580	1,102	2,224	0	60.08
Kerala	38,863	1,523	9,301	8,415	19,239	36	49.50
Sikkim	7,096	500	2,160	697	3,357	311	47.31
Uttarakhand	53,483	4,754	13,602	5,884	24,240	307	45.32
Dadra & Nagar Haveli	491	0	80	126	206	5	41.96
Chhattisgarh	135,191	4,152	34,846	16,588	55,586	117	41.12
Assam	78,438	1,441	11,268	14,914	27,623	384	35.22

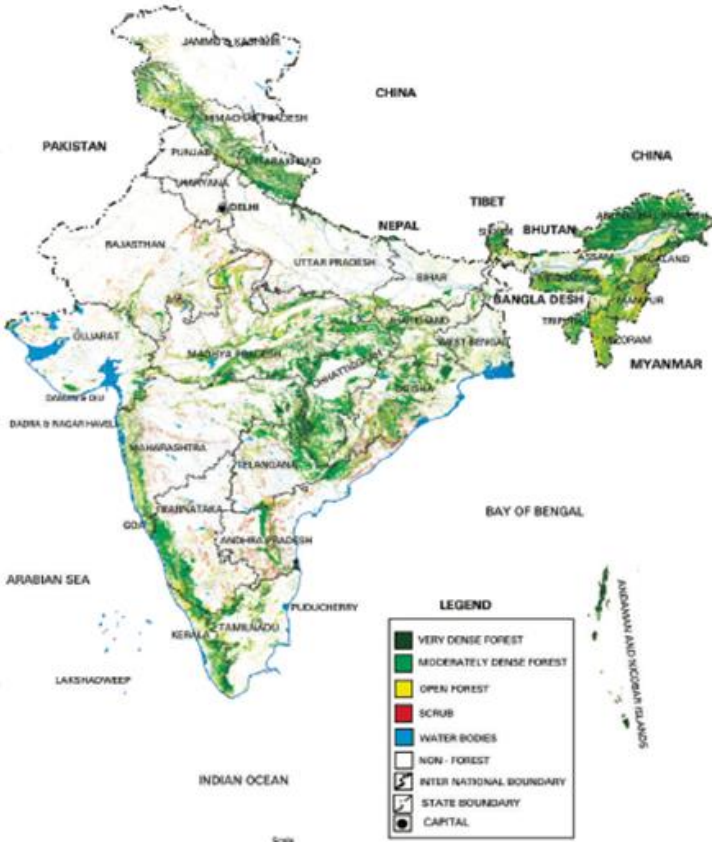
Difference between forest area and forest cover

- The term 'Forest Area' (or recorded forest area) generally refers to all the geographic areas recorded as forest in government records. Recorded forest areas largely comprise Reserved Forests (RF) and Protected Forests (PF), which have been constituted under the provisions of Indian Forest Act, 1927. Besides RFs and PFs, the recorded forest area may include all such areas, which have been recorded as forests in the revenue records or have been constituted so under any State Act or local laws.
- On the other hand, the term 'Forest Cover' as used in the 'SFR' refers to all lands more than one hectare in area, having a tree canopy density of more than 10%. Thus the term 'forest area' denotes the legal status of the land as per the government records, whereas the term 'forest cover' indicates presence of trees over any land.



On the basis of the percentage of the actual forest cover, the states can be grouped into four regions:

The Region and Percentage Cover of the Forest	**States**
(i) The region of high concentration > 40	Mizoram (88.93%), Lakshadweep (84.56%), A & N Islands (81.84%), Arunachal Pradesh (80.3%), Nagaland (78.21%), Meghalaya (76.76%), Manipur (76.11%),Tripura (74.49%), Goa (60.08%), Sikkim (47.31%), Uttarakhand (45.32%), Kerala (49.5%), Dadra & Nagar Haveli (41.96%), Chhattisgarh (41.12%)
(ii) The region of medium concentration 20-40	Assam (35.22%), Orissa (32.34%), Jharkhand (29.45%), Himachal Pradesh (26.40%), Madhya Pradesh (25.13%), Tamil Nadu (20.26%)
(iii) The region of low concentration 10-20	Karnataka (18.99%), Telengana (18.80%), Andhra Pradesh (15.25%), Maharashtra (16.45%), Daman & Diu (17.51%), Chandigarh(19.32%),West Bengal (18.96%), Delhi (12.73%), Puducherry (11.54%), Jammu & Kashmir (10.34%)
(iv)The region of very low concentration < 10	Gujarat (7.48 %), Bihar (7.74%), Uttar Pradesh (6%), Rajasthan (4.73%), Haryana (3.58%), Punjab (3.52%)



FOREST COVER CHANGE MATRIX FOR INDIA BETWEEN ISFR 2013 AND ISFR 2015

2105 Assessment

Gain / Loss	Very dense forest	Moderately dense forest	Open forest	Scrub	Non-forest	Total IFSR 2013
Very dense forest	82,473	623	145	4	257	83,502
Moderately dense	2,897	311,063	2,438	93	2,254	318,745
forest	362	2,580	286,491	596	5,622	295,651
Open forest	15	130	1,496	38,068	1,674	41,383
Scrub	157	978	9,825	2,601	2,534,421	2,547,982
Non-forest	**85,904**	**315,374**	**300,395**	**41,362**	**2,544,228**	3,387,263
Total ISFR 2015	2,402	-3,371	4,744	-21	-3,754	

**Source II: Forest Survey of India (FSI) biennial report (December 2015)

Class	2013 Assessment		2015 Assessment		Change
	km²	% of GA	km²	% of GA	km²
Forest Cover	697,898	21.23	701,673	21.34	3775
Tree Cover	91,266	2.78	92,572	2.82	1306
Total	789,164	24.01	794245	24.15	5081

3.4.2. OTHER CLASSIFICATIONS OF FORESTS

1. Constitutional Basis

According to the Constitution of India the forests in India have been classified under the following three categories for the sake of their ownership, administration and management:

- **State forests:** These are under the full control of the government (state/central) and include almost all the important forest areas of the country. More than 90 per cent of the country's forest area belongs to this category.
- **Communal forests:** These forests are owned and administered by the local bodies (municipal corporation, municipal board, town area, district board, village panchayat etc.) and occupy about 5 per cent of the country's forest area.
- **Private forests:** These are under the private ownership and cover little more than 1 per cent of the forested area of the country. Many of these forests are degraded and in bad condition and have been converted into waste lands. Such forests are mainly found in Orissa, Meghalaya, Punjab and Himachal Pradesh.

2. Administrative Basis

Indian forests were classified under following three categories during the British rule and they continue to be done today as well:

- **Reserved forests:** These forests are under the direct supervision of the government where no public entry is allowed for collecting timber and grazing of cattle. About half of forest area has been declared as the Reserved Forests by the government. They are regarded as the most valuable as far as conservation of forest and wildlife resources are concerned.
- **Protected forests:** These forests are looked after by the government but here local people are allowed to collect timber/fire wood and graze their cattle without causing serious damage to the forests. Almost one third of total forest area is protected forest as declared by the Forest Department. This forest land is protected from any further depletion.
- **Unclassified forests:** These are unclassified forests where there is no restriction on the cutting of trees and cattle grazing. These are other forests and wasteland belonging to both government and private entities.

Merchantability basis: On the basis of merchantability, Indian forests may be grouped under two categories:

- **Merchantable:** Forests which are **accessible**. About 82% of forests belong to this group
- **Non-merchantable:** These are **inaccessible** mostly situated in high hills. About 18% forests, mostly conifers fall under this category.

Based on type of leaves:

- **Coniferous forests:** These are temperate forests found over the Himalayan ranges and occupying 6.43% of total forest area.
- **Broad leaf forests:** About 93.57% of the country's forest area belongs to this category. These are tropical and sub-tropical forests occupying the plains, plateaus and hill slopes and yielding good quantity of timber and forest products

Based on Canopy Density: FSI categorises forests based on the canopy density:

- **Scrubs:** The degraded forest lands which have a Canopy density of less than 10% are called Scrubs.
- **Open Forests:** The Lands with Canopy density of 10-40% are called Open Forests.
- **Moderately Dense Forest:** The Land with forest cover having a canopy density of 40-70% is called the Moderately Dense Forest (MDF).
- **Very Dense Forests:** The Lands with forest cover having a canopy density of 70% and more are called Very Dense Forests (VDF)

3.4.3. NATIONAL FOREST POLICY 1988

India adopted a forest policy in 1952, which was further modified in 1988. According to the new forest policy, the Government will emphasise sustainable forest management in order to conserve and expand forest reserve on the one hand, and to meet the needs of local people on the other.

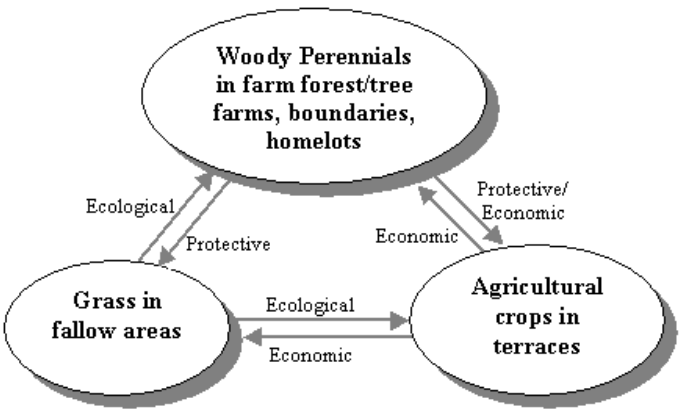
The forest policy of the Government of India aims at:

i. bringing 33 per cent of the geographical areas under forest cover;
ii. maintaining environmental stability and to restore forests where ecological balance was disturbed;
iii. conserving the natural heritage of the country, its biological diversity and genetic pool;
iv. checks soil erosion, extension of the desert lands and reduction of floods and droughts;
v. increasing the forest cover through social forestry and afforestation on degraded land;
vi. increasing the productivity of forests to make timber, fuel, fodder and food available to rural population dependant on forests, and encourage the substitution of wood;
vii. Creating of a massive people's movement involving women to encourage planting of trees, stop felling of trees and thus, reduce pressure on the existing forest.

3.5. SOCIAL FORESTRY

Social forestry means the management and protection of forests and afforestation on barren lands with the purpose of helping in the environmental, social and rural development. The National Commission on Agriculture (1976) has classified social forestry into three categories. These are urban forestry, rural forestry and Farm forestry.

- **Urban forestry** pertains to the raising and management of trees on public and privately owned lands in and around urban centres such as green belts, parks, roadside avenues, industrial and commercial green belts, etc.
- **Rural forestry** lays emphasis on promotion of agro-forestry and community-forestry.
- **Agro-forestry** is the raising of trees and agriculture crops on the same land inclusive of the waste patches. It combines forestry with agriculture, thus, altering the simultaneous production of food, fodder, fuel, timber and fruit.



AGROFORESTRY SYSTEM

- **Community forestry:**
  - It involves the raising of trees on public or community land such as the village pasture and temple land, roadside, canal bank, strips along railway lines, and schools etc.
  - Community forestry programme aims at providing benefits to the community as a whole.
  - Community forestry provides a means under which the people of landless classes can associate themselves in tree raising and thus, get those benefits which otherwise are restricted for landowners.
- **Farm forestry:** It is a term applied to the process under which farmers grow trees for commercial and non-commercial purposes on their farm lands. Forest departments of various states distribute seedlings of trees free of cost to small and medium farmers.

Wetlands – Refer the material on Wetlands provided separately.

3.6. BIOMES

What is a biome?

The large natural ecosystem comprised of abiotic (land, air, water and soils of the concerned habitat) and biotic (plants, animals and micro-organisms) components wherein all the biota have minimum common characteristics, and more or less uniform environmental conditions is called biome.

There are five major biomes — forest, desert, grassland aquatic and altitudinal biomes.

Some features of these biomes are given in this Table.

Biomes	Subtypes	Regions	Climatic Characteristics	Soil	Flora and Fauna
Forest	A. Tropical 1. Evergreen 2. Deciduous B. Temperate C. Boreal/ Taiga	A1. 10° N-S A2. 10°-25° N-S B. Eastern North America, N.E. Asia, Western and Central Europe C. Broad belt of Eurasia and North America (parts of Siberia, Alaska, Canada and Scandinavia)	A1. Temp. 20-25°C, Rainfall, ave. ann. 2,000mm,evenly distributed A2. Temp. 25-30°C, Rainfall, ave. ann. 1,000mm, seasonal B. Temp. 20-30° C, Rainfall evenly distributed 750-1,500mm, Well defined seasons and distinct winter. C. Short moist moderately warm summers and long cold dry winter; very low temperatures. Precipitation mostly snowfall 400 - 1,000mm	A1. Acidic, poor in nutrients A2. Rich in nutrients B. Fertile, en-riched with decaying litter C. Acidic and poor in nutrients, thin soil cover	A1. Multi-layered canopy tall and large trees A2. Less dense, trees of medium height; many varieties coexist. Insects, bats, birds and mammals are common species in both B. Moderately dense broad leaved trees. With less diversity of plant species. Oak, Beach, Maple etc. are some common species. Squirrels, rabbits, skunks, birds, black bears, mountain lions etc. C. Evergreen conifers like pine, fur and spruce etc. Wood peckers, hawks, bears, wolves, deer, hares and bats are common animal
Desert	A. Hot and Dry desert B. Semi arid desert C. Coastal desert D. Cold	A. Sahara, Kalahari, Marusthali, Rub-el-Khali B. Marginal areas of hot deserts C. Atacama	A. Temp. 20-45°C 35°C. B. 21-38°C C. 15-35°C D. 2 - 25°C A-D Rainfall is less than 50 mm	Rich in nutrients with little or no organic matter	A-C. Scanty vegetation; few large mammals, insects, reptiles and birds D. Rabbits, rats, antelopes and ground squirrels

	desert	D. Tundra climatic regions			
Grassland	A. Tropical Savannah B. Temperate Steppe	A. Large areas of Africa, Australia, South America and India B. Parts of Eurasia and North America	A. Warm hot climates, Rainfall 500-1,250 mm B. Hot summers and cold winter. Rainfall 500 - 900 mm	A. Porous with thin layer of humus. B. Thin flocculated soil, rich in bases	A. Grasses; trees and large shrubs absent; giraffes zebras, buffalos, leopards, hyenas, elephants, mice, moles, snakes and worms etc., are common animals B. Grasses; occasional trees such as cottonwoods, oaks and willows; gazelles, zebras, rhinoceros, wild horses, lions, varieties of birds, worms, snakes etc., are common animals
Aquatic	A. Freshwater B. Marine	A. Lakes, streams, rivers and wetlands B. Oceans, coral reefs, lagoons and estuaries	A-B Temperatures vary widely with cooler air temperatures and high humidity	A. Water, swamps and marshes B.Water, tidal swamps and marshes	Algal and other aquatic and marine plant communities with varieties of water dwelling animals
Altitudinal		Slopes of high mountain ranges like the Himalayas, the Andes and the Rockies	Temperature and precipitation vary depending upon latitudinal zone	Regolith over slopes	Deciduous to Tundra vegetation varying according to altitude

3.6.1. FOREST BIOME

Forest is the ultimate vegetation type which results from the process of succession on land areas, unless local conditions such as climate, soil or biotic factors arrest development. Trees can be divided into the two main types: evergreen, which always have leaves, and deciduous, which have no leaves at all at some stage, usually in the winter or dry season. Many naturalists have devised differing classifications of forests in relation to climatic zones, but there is general agreement in distinguishing boreal, temperate deciduous and tropical rain forests.

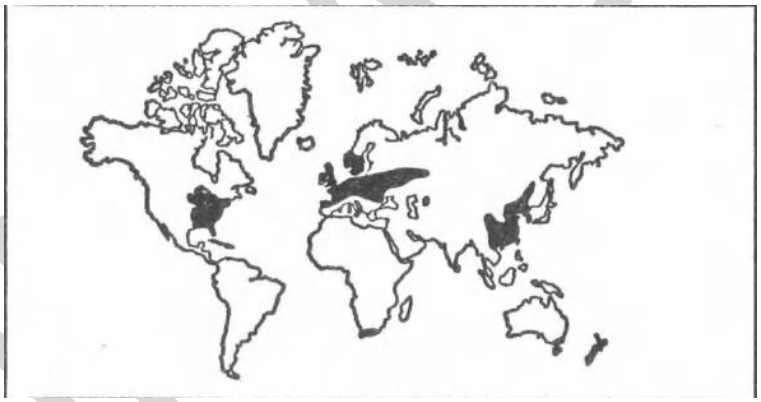
3.6.1.1. The tropical rain-forests

- **Location**: It occupies low-altitude areas near the equator in South America, Central and West Africa, and in the Indo-Malay peninsula and New Guinea regions.
- **Climate:** The Temperature is high throughout the year and the average range is 20-25°C while the average annual rainfall is 2,000mm and evenly distributed.
- **Flora:** It is a broad-leaved evergreen forest of dense, prolific growth and an extremely diverse fauna and flora.
- The hot, wet tropical climate is highly conducive to plant growth and there is very little seasonality which means that the growing period extends throughout the year.

- In these conditions there will be severe competition for survival, leading to specialisation of roles and the predominance of narrow ecological niches.
- All green plants strive to reach the light so that they either become very tall, or adopt a climbing habit like many climbers or live as epiphytes (plants living on other plants but not deriving food from them).
- Beneath the tree canopy, which may itself consist of two layers, there is usually a well-developed layering of understorey vegetation which is so dense that hardly any light reaches ground level.
- The leaves possess thick cuticles for protection against the strong sunlight, anddrip tips whose probable function is to shed water rapidly, thereby aiding transpiration.
- **Fauna:** The heterotrophs also show similarities in their general characteristics.
- Some animals have developed the ability to glide in the air like fox, tree frogs, squirrels, tree snakes etc. Some mammals have large and sturdy bodies to push plants away like chimpanzee, gorilla, bison, African Elephant etc.
- Many snakes and mammals are adapted to live in the trees because this is where the bulk of the foliage exists.

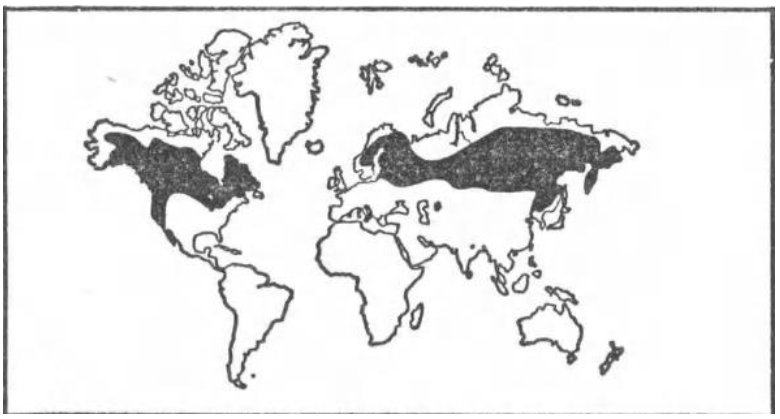
3.6.1.2. Temperate Deciduous Forest

- This type of forest is dominated by broad-leaved deciduous trees.
- The trees have deciduous character where they shed their leaves seasonally
- **Location:** It covers most of the temperate areas of Europe, eastern North America, eastern Asia and small parts of South America and Australia.



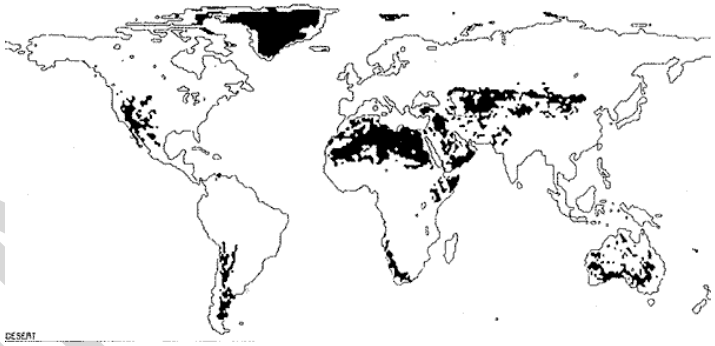
- **Climate:** There is a longer growing season, higher light intensity and a moderate amount of precipitation of between 500 and 1500 mm per annum.
- The temperature regime is also characterised by lack of extremes but there is still a marked cold season which plants and animals must endure.
- **Flora:** There are at least sixty dominant species, notably several sorts of chestnut, maple and hemlock.
- The deciduous habit and the lighter shade cast by these trees, allows sufficient light to reach beneath the canopy so that understorey vegetation can develop.
- **Fauna:** The animal range from very small animals to large bodied animals like elephants, hippopotamus, lions, rhinos etc.
- **Soils:** The soils associated with the temperate deciduous forest are varied but on the whole they are brown earths.
- The temperate deciduous forest has probably been more modified by human activity than any other type of ecosystem.

3.6.1.3. Boreal Forest or Taiga



- The boreal forest formation is a vast expanse of coniferous, evergreen forest.
- **Location:** It extends across North America and Eurasia on the southern margins of the tundra zone.
- **Climate:** The growing season is only of three or four months' duration and even during this time; the energy input from solar radiation is small because of the high latitude.
- Temperatures are low throughout the year, although the average temperature of the warmest month of the year is higher than 10° C.

- In the winter the temperatures fall to many degrees below freezing and permafrost frequently extends into the northern edge of the forest.
- Precipitation ranges from 400 to 1000 mm per annum, mostly falling as snow.
- Despite the climate, coniferous trees form a dense canopy which intercepts a great amount of light and precipitation so that conditions beneath are dark and dry.
- Consequently there is little opportunity for undergrowth to develop and very few other plants are associated with the coniferous trees.
- **Flora:** The trees themselves show very little variety across the formation; species of pine, fir and spruce tend to be dominant throughout.
- The trees grow needles instead of leaves, and cones instead of flowers. The needle-like leaves have a waxy outer coat which prevents water loss in freezing weather and the branches are soft and flexible and usually point downwards, so that snow slides off them.
- Conifers tend to be evergreen, that is, they bear needles all year long.
- **Fauna:** At the herbivore level the invertebrates are predominant, the vertebrate herbivores only becoming numerous in areas where foliage is thicker.
- Carnivores, such as the wolf and lynx, and the large omnivores, such as the black and grizzly bears, which need a lot of food to maintain themselves, are scarce.
- **Soils:** Characteristically the boreal forest is found growing on podzols which tend to become highly acidic

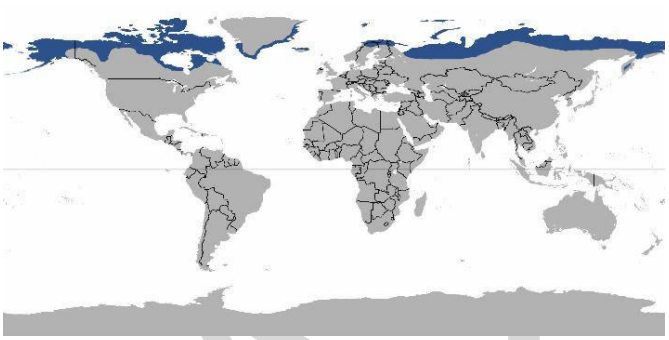


3.6.2. DESERTS BIOME

- **Location:** This biome is mainly found in the hot arid zones of the world, such as the Sahara and Australian deserts. Some cooler deserts–for example, those of the Gobi and Patagonia–are also found.
- Hot deserts occur in the subtropical dry zone of the global atmospheric circulation system
- **Flora:** Up to 60 per cent of desert floras are made up of annual or ephemeral species which evade the drought by completing their life cycles within a few weeks of the onset of any rain.
- One of the most important ways of avoiding water loss is to close the leaf stomata, particularly during the hottest period of the day, yet the stomata need to be kept at least partly open to maintain transpiration and cool the leaves. Some plants only open their stomata at night.
- Succulents, such as cacti, combat the water problem with the aid of well-developed water storage organs and small surface area to volume ratios.
- An evasion of the worst effects of high salt concentrations in the saline ground conditions may be achieved by the synchronisation of life cycles with rain periods sufficiently wet to leach temporarily the upper soil layers. Thus besides their xerophytic characteristics, many plants need also to be halophytic.
- The most noticeable visual characteristic of areas of desert vegetation is the discontinuous cover and the even spacing of individuals. This appears to be the result of extensive root development and competition.
- Vegetation is more discontinuous than in the tundra, but on the other hand it is more diverse in composition and form.
- Related to varying degrees of aridity, desert vegetation includes low woody scrub formations, cacti communities, intermittent swards of perennial grass tufts, ephemeral or seasonal herbaceous vegetation, and 'accidental' vegetation in areas where rainfall may occur only once in several years
- In the particularly harsh conditions of the coastal deserts where the sole source of moisture is the sea mist, only halophytes or succulent epiphytes, absorbing moisture directly from the atmosphere, can survive.
- **Fauna:** As in the tundra, the animal species of deserts are fewer but more specialised than in humid environments. Morphological protection may be given by such features as an impermeable body covering, a small number of sweat glands and a light colouring. Camels and donkeys have in addition a physiological tolerance of high water losses and can survive a water reduction equal to more than 25 per cent of body weight.

- In smaller animals the burrowing habit is widely developed, especially among insects. Nocturnal activity and summer dormancy are also common features.
- The close interrelationship between the lack of vegetation cover and the unstable geomorphological environment gives deserts a character of delicate instability in which they are particularly susceptible to disruption by man.

3.6.3. TUNDRA



- **Location:** The tundra includes all types of vegetation found in high latitudes between the limits of tree growth and the polar ice-caps
- Permafrost is common over large areas.
- **Climate:** In broad terms, climates range from a continental type of extremely cold winters and little snow precipitation, as in Siberia and northern Canada, to the raw maritime conditions of southern Greenland, northern Norway and Alaska.
- **Flora:** Plants in the tundra adapt to these unfavourable conditions in several ways, so that in some species cellular ice does not form until temperatures drop below — 30°C. Other plants, such as lichens, never freeze and can adjust to rapid and extreme temperature changes.
- Where undisturbed, the southern parts of the tundra are characterised by stands of dwarf willow, birch and alder, sometimes up to two metres in height. Further north, these give way to heaths of cowberry or crowberry.
- **Fauna:** Animals in the tundra are limited in number and variety by the lack of plant food and the intense cold. Warm-blooded animals must either be protected from the surface cold by such adaptations as woolly coats and low surface area to body volume ratios, as in the polar bear, or they must migrate.
- Cold-blooded animals, of which the insects are by far the most numerous, can survive in larval form throughout the winter.
- The main herbivores include caribou, reindeer, musk ox, lemmings and the Arctic hare; predators, both carnivores and omnivores, include the Arctic fox, the wolf and bears

3.6.4. GRASSLANDS BIOME

3.6.4.1. Temperate Grasslands

- **Location:** These include the prairies of North America, the steppes of Eurasia, the pampas of South America, and the veldt of South Africa, downs of Australia and Canterbury grasslands of New Zealand.
- **Climate:** The temperate grasslands of northern hemisphere are characterized by continental climate wherein extremes of summer and winter temperatures are well marked but the temperate grasslands of the southern hemisphere are characterized by more moderate climate.
- Precipitation in these areas ranges from 500 to 900 mm per annum, and the grasslands extend over a wide range of soil conditions.
- **Flora:** Trees only occur on steep slopes or near water.
- The geographical isolation of these areas from each other has led to some species differentiation, but most other features are similar.
- **Fauna:** Grasslands are dominated by few species of large mammals like buffalo and pronghorn antelope in North American Prairies; wild horse and saiga antelope in the Eurasian steppes; antelopes in the South African velds and guanaco in the South American pampas.
- **Soils:** Soils within the prairie belt include deep and fertile chernozems, prairie soils and chestnut soils.

- Although the boundaries of the prairies seem to have fluctuated in the geologicalpast, one of the most interesting features is the sharpness of the prairie edge, and the lack of an ecotone or transitional area with adjacent forests.
- The factors which have created this situation are difficult to isolate, but most would include grazing and fire.

3.6.4.2. Tropical Grasslands (Savannas)

- The savanna lands of Africa, South America and Australia are essentially open, and ecologically dominated by a herbaceous stratum in which grasses and sedges are the principal components.
- **Location:** They are found in large areas of Africa, Australia, South America and India
- The **climate** is characterized by distinct wet and dry seasons and means high temperature throughout the year
- All types experience a climate of marked seasonal drought.
- **Flora:** Greater diversity of tropical as opposed to temperate grasslands is often a function of the added variety afforded by wooded plants. In some cases the tree cover may be as much as 50 per cent; in others it may be nil.
- Many of the plants, grasses and woody species, exhibit xerophytic features.
- Marked contrasts exist in the appearance of the savanna during the year: the brown and withered short grasses of the dry season give way rapidly to tall lush growth with the arrival of the summer rains.
- **Fauna:** The African Savanna accounts for the largest number and greatest variety of grazing vertebrate mammals in the world. African buffalo, zebra, giraffe, elephants, many types of antelopes, hippopotamus are some examples.
- South American and Australian Savanna do not have large number of grazing animals like African Savanna but great variety of birds. Australian Savanna is dominated by marsupials (mammals having pouch in their bodies to keep and feed their offsprings).
- **Soils:** The ferralsolic soils of savanna areas frequently include near-surface lateritic crusts, creating an impermeable surface soil layer in which nutrients, especially phosphates and nitrates, are markedly lacking.
- As in the case of prairies, tropical grasslands tend to show little ecotone development, especially on margins adjacent to tropical rain-forest.
- Factors of soil, fire and grazing are important in maintaining the character of tropical grasslands.
- Many of the tree species appear to be fire-resistant.
- There is a great variety of herbivores and carnivores in this biome.

3.6.5. THE AQUATIC BIOME

Life forms in these waters depend on the abiotic factors such as sunlight entering the waters, temperature, pressure, salt content and so on. Water biomes with lots of light tend to have more flora (plant) diversity and the growth of algae and plankton is more. Small water bodies that freeze during the cold seasons, or dry out in the dry and hot seasons tend to have less diversity. Aquatic biomes are very important because apart from being home to millions of water animals, they also form the basis of the water cycle and help with atmospheric moisture, cloud formation and precipitation. One example of a marine biome is the Great Barrier Reef (a coral reef system) of Australia.

3.6.5.1. Freshwater Biome

- Freshwater is defined as having a low salt concentration — usually less than 1%. Plants and animals in freshwater regions are adjusted to the low salt content and would not be able to survive in areas of high salt concentration (i.e., ocean).
- There are 3 different types of freshwater regions:
  - Ponds and Lakes
  - Streams and Rivers
  - Wetlands (sometimes considered brackish water)

3.6.5.2. Marine Biome

- Marine regions cover about three-fourths of the Earth's surface and include oceans, coral reefs, and estuaries. Marine algae supply much of the world's oxygen supply and take in a huge amount of atmospheric carbon dioxide. The evaporation of the seawater provides rainwater for the land. Oceans cover 70 per cent of the surface area of the world, they are habitable throughout and support a total biomass probably as much as ten times that on land.
- Types: Oceans, Corals reefs, Estuaries
- The ocean regions are separated into separate zones: intertidal, pelagic, abyssal, and benthic. All four zones have a great diversity of species.
- The intertidal zone is where the ocean meets the land — sometimes it is submerged and at other times exposed, as waves and tides come in and out. Because of this, the communities are constantly changing. On rocky coasts, the zone is stratified vertically. In areas where only the highest tides reach, there are only a few species of algae and molluscs; in areas usually submerged during high tide, there is a more diverse array of algae and small animals. At the bottom of the intertidal zone, which is only exposed during the lowest tides, many invertebrates, fishes, and seaweed can be found.
- The pelagic zone includes those waters further from the land, basically the open ocean. The pelagic zone is generally cold though it is hard to give a general temperature range since, just like ponds and lakes; there is thermal stratification with a constant mixing of warm and cold ocean currents. The flora in the pelagic zone includes surface seaweeds. The fauna include many species of fish and some mammals, such as whales and dolphins. Many feed on the abundant plankton.
- The benthic zone is the area below the pelagic zone, but does not include the very deepest parts of the ocean (see abyssal zone below). The bottom of the zone consists of sand, slit, and/or dead organisms. Here temperature decreases as depth increases toward the abyssal zone, since light cannot penetrate through the deeper water. Flora are represented primarily by seaweed while the fauna, since it is very nutrient-rich, include all sorts of bacteria, fungi, sponges, sea anemones, worms, sea stars, and fishes.
- The deep ocean is the abyssal zone. The water in this region is very cold (around 3° C), highly pressured, high in oxygen content, but low in nutritional content. The abyssal zone supports many species of invertebrates and fishes. Mid-ocean ridges (spreading zones between tectonic plates), often with hydrothermal vents, are found in the abyssal zones along the ocean floors. Chemosynthetic bacteria thrive near these vents because of the large amounts of hydrogen sulfide and other minerals they emit. These bacteria are thus the start of the food web as they are eaten by invertebrates and fishes

3.7. ECO SENSITIVE ZONES

- **What are Eco Sensitive Zones?**
  - The National Wildlife Action Plan (2002–2016) of the Ministry of Environment, Forest and Climate Change (MoEFCC) stipulated that state governments should declare land falling within 10 km of the boundaries of national parks and wildlife sanctuaries as eco fragile zones or ESZs under section 3 (v) of the Environmental (Protection) Act, 1986.
- **Why ESZ's**
  - The purpose of the ESZ was to provide more protection to the parks by acting as a shock absorber or transition zone.
  - Transition zones around protected forest areas would minimise forest depletion and man-animal conflict.
  - The protected areas are based on the core and buffer model of management. The core area has the legal status of being a national park. The buffer area, however, does not have legal status of being a national park and could be a reserved forest, wildlife sanctuary or tiger reserve.
  - This will help in protecting endangered species.
  - This will also promote eco-tourism.
- **Eco-Sensitive Zone Guidelines**
  - The guidelines proposed that the boundary had to be site specific, decided in consultation with a field based team comprising representatives from the forest department, revenue department and Panchayati Raj institution.

- Though ESZ does not affect the ownership rights of people on land resources, it restricts land-use change. Activities such as widening of roads, construction or expansion of buildings, change of the agriculture system and erection of electric cables will also be regulated by a monitoring committee, mostly comprising of government officials, as per the master plan of the ESZ.
- It mentioned that the ESZs are not anti-people and do not intend to hamper their everyday activities.

- **Concerns of local people**
  - Locals claim that it is against their livelihood.
  - There is no compensation for damage to crops by animals.
  - Man-animal conflict may increase.
  - Local people will be treated as encroachers.
  - There are no policies to regulate tourism. Hotels and mega resorts, dominate the area and locals are restricted to low paying jobs. The locals are not enthusiastic in the ecotourism business as mass tourism gives them tough competition.
- **Other issues.**
  - Worried about how the process would hit development and apparently under pressure from mining and industry lobbies, the states have excluded several ecologically important areas around wildlife parks and sanctuaries from being protected.
  - The presence of minerals and resources near Protected Areas has disrupted the identification of ESZs in many states too.
  - The communities around eco-sensitive areas are also in uproar because they have been excluded from the process of identifying and governing the eco-sensitive zones (ESZs).
  - Also the ESZ guidelines do not restrict the current tourism practices or put any restriction on the vehicular pollution in the area.

Western Ghats and various committees

- **Western Ghats Ecology Expert Panel (WGEEP)** headed by **Madhav Gadgil** was formed by MoEF in 2010.
- It's ***recommendations*** were:
  - ✓ Make entire Western Ghats region ecologically-sensitive area. This would be divided into two parts: The protected areas which will be the national parks and wildlife sanctuaries; three Ecological Sensitive Zones (ESZ) viz. ESZ-1, ESZ-2 and ESZ-3, with different degrees of protection.
  - ✓ Highest protection in ESZ-1 and ESZ-2 categories. It recommended that the government should put an indefinite moratorium on new environmental clearances for mining in ESZ-1 and ESZ-2 and phasing out of mining from ESZ-1 by 2015. The continuation of existing mining in ESZ-2 under strict regulation with an effective system of social audit.
  - ✓ It also recommended that no new dams based on large-scale storage be permitted in ESZ-1.
  - ✓ The demarcation of the ESZs should be based on participation from local communities and local bodies
  - ✓ It also recommended constitution of a Western Ghats Ecology Authority (WGEA), as a statutory authority under the Ministry of Environment and Forests to focus on local participation and sustainability.
- There was a lot of controversy and criticism of the recommendations as states felt that it would hamper energy and development projects. The ban on dams adversely impacted power sector. Locals also were against the report as the perception was that it would adversely impact livelihood. Then, the Kasturirangan committee was constituted to examine the WGEEP report.
- It is called HLWG, meaning **10 member high-level working group (HLWG)**, headed by **Kasturirangan**.
- The ***recommendations*** were:
  - ✓ Instead of the total area of Western Ghats, only 37% (i.e. 60,000 sq. km.) of the total area be brought under ESA under Kasturirangan report.
  - ✓ Complete ban on mining, quarrying and sand mining in ESA.
  - ✓ Distinguished between *cultural* (58% occupied in Western Ghats by it like human settlements, agricultural fields and plantations) *and natural* landscape (90% of it should come under ESA according to committee).
  - ✓ Current mining areas in the ESA should be phased out within the next five years, or at the time of expiry of mining lease, whichever is earlier.

- ✓ No thermal power should be allowed and hydropower projects be allowed only after detailed study.
  - There were criticisms of these recommendations as it used aerial survey methods and remote sensing techniques for demarcation without examining ground realities. Also, there was no power to gram sabhas.
- **Recent Developmets**
  - The Minister of State (Independent Charge),Environment, Forest & Climate Change Javadekar said as per the Kasturirangan Committee report, commercial mining and polluting industries would be strictly banned in areas identified as eco sensitive zones in Western Ghats.
  - He also said that every State will be given full opportunity for development works and the Union Ministry is currently going through the proposals submitted by State Ministers.
  - Since more than 4,000 villages fell in the proposed eco-sensitive zones, consultation with local population was on to seek their recommendation on the plan of action and the process would be completed by month-end.
- **Conclusion**
  - The need for conservation of vrgetation and wildlife cannot be doubted and ESZ's are steps towards the same.
  - However, there is a need for rethinking on the impacts of the environmental policies at the local level, the type and prospects of local participation and most importantly the prospects of alternate income generating opportunities for successful conservation initiatives.

3.8. PREVIOUS YEAR UPSC QUESTIONS

1. Discuss the wetlands and their role in ecological conservation in India. (UPSC 2009/15 Marks)
2. Mention the area of Shola forests in India. (UPSC 2003/2 Marks)
3. What are mangroves and in what way are they useful to us? (UPSC 2001/10 Marks)
4. What is waste land? Write a note on prospects of waste land development in India. (UPSC 2000/10 Marks)
5. Why has there been opposition from the North-Eastern States to the Supreme Court ban on all activities inside forests? (UPSC 1997/10 Marks)
6. Where do mangrove forests occur in India? Describe their main characteristics. (UPSC 1996/15 Marks)
7. Which parts of India are described as 'arid zones'? Comment on the characteristics and economic activities prevalent in these regions? (UPSC 1993/15 Marks)
8. Where do we find large desert areas in India? What steps have been taken by the Government for their development? (UPSC 1985/20 Marks)
9. Which is the largest expanse of tidal forests in India and in which State is it located? (UPSC 1981/3 Marks)

3.9. PRELIMS QUESTIONS

1. 'Each day is more or less the same, the morning is clear and bright with a sea breeze; as the Sun climbs high in the sky, heat mounts up, dark clouds form, then rain comes with thunder and lightning. But rain is soon over'. (2015)
Which of the following regions is described in the above passage?
(a) Savannah (b) Equatorial
(c) Monsoon (d) Mediterranean
Correct Answer: (b)

2. If you travel through the Himalayas, you are likely to see which of the following plants naturally growing there? (2014)
1. Oak
2. Rhododendron
3. Sandalwood
Select the correct answer using the code given below
(a) 1 and 2 only (b) 3 only
(c) 1 and 3 only (d) 1, 2 and 3
Correct Answer: (a)

3. In the grasslands, trees do not replace the grasses as a part of an ecological succession because of- (2013)

(a) insects and fungi
(b) limited sunlight and paucity of nutrients
(c) water limits and fire
(d) None of the above

Correct Answer: (c)

4. Which of the following leaf modifications occurs/occur in desert areas to inhibit water loss? (2013)

1. Hard and waxy leaves
2. Tiny leaves or no leaves
3. Thorns instead of leaves

Select the correct answer using the codes given below.

(a) 1 and 2 only
(b) 2 only
(c) 1 and 3 only
(d) 1, 2 and 3

Correct Answer: (d)

5. "Climate is extreme, rainfall is scanty and the people used to be nomadic herders." The above statement best describes which of the following regions? (2013)

(a) African Savannah
(b) Central Asian Steppe
(c) North American Prairie
(d) Siberian Tundra

Correct Answer: (b)

6. Which of the following is/are unique characteristic/characteristics of equatorial forests? (2013)

1. Presence of tall, closely set trees with crowns forming a continuous canopy
2. Coexistence of a large number of species
3. Presence of numerous varieties of epiphytes

Select the correct answer using the codes given below:

(a) 1 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Correct Answer: (d)

7. Which one of the following is the characteristic climate of the Tropical Savannah Region? (2012)

(a) Rainfall throughout the year
(b) Rainfall in winter only
(c) An extremely short dry season
(d) A definite dry and wet season

Correct Answer: (b)

8. What is the difference between the antelopes Oryx and Chiru? (2012)

(a) Oryx is adapted to live in hot and arid areas whereas Chiru is adapted to live in steppes and semi-desert areas of cold high mountains.
(b) Oryx is poached for its antlers whereas Chiru is poached for its musk.
(c) Oryx exists in western India only whereas Chiru exists in north-east India only.
(d) None of the statements (a), (b) and (c) given above is correct.

Correct Answer: (a)

9. If a tropical rain forest is removed, it does not regenerate quickly as compared to a tropical deciduous forest. This is because: (2011)

(a) The soil of rain forest is deficient in nutrients
(b) Propagules of the trees in a rain forest have poor viability
(c) The rain forest species are slow growing
(d) Exotic species invade the fertile soil of rain forest

Correct Answer: (a)

10. The Himalayan Range is very rich in species diversity. Which one among the following is the most appropriate reason for this phenomenon? (2011)

(a) It has high rainfall that supports luxuriant vegetative growth
(b) It is a confluence of different bio-geographical zones
(c) Exotic and invasive species have not been introduced in this region.
(d) It has less human interference

Correct Answer: (b)

11. In India, which type of forest among the following occupies the largest area? (2010)
(a) Montane Wet Temperate Forest (b) Sub-tropical Dry Evergreen Forest
(c) Tropical Moist Deciduous Forest (d) Tropical Wet Evergreen Forest
Correct Answer: (c)

12. The approximate representation of land use classification in India is (2010)
(a) Net area sown 25%; forest 33%; other areas 42%
(b) Net area sown 58%; forest 17%; other areas 25%
(c) Net area sown 43%; forest 29%; other areas 28%
(d) Net area sown 47%; forest 23%; other areas 30%
Correct Answer: (d)

13. Consider the following statements: (2010)
1. Biodiversity hotspots are located only in tropical regions.
2. India has four biodiversity hotspots i.e., Eastern Himalayas, Western Himalayas, Western Ghats and Andaman and Nicobar Islands.
Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2
Correct Answer: (d)

14. Consider the following statements: (2010)
1. The Taxus tree naturally found in the Himalayas.
2. The Taxus tree is listed in the Red Data Book.
3. A drug called "taxol" is obtained from Taxus tree is effective against Parkinson's disease.
Which of the statements given above is/are correct?
(a) 1 only (b) 1 and 2 only (c) 2 and 3 only (d) 1, 2 and 3
Correct Answer: (b)
Explanation: Taxus wallichiana Zucc., is found in temperate forests of Asia ranging from Afghanistan through the Himalayas to the Philippines with elevation range of 1500-3500 m. it is small to medium-sized tree, with red 'berries' (seeds covered by arils), valuable for Taxol extraction. It is used in preparation of anticancer drugs, in addition to other medicinal uses in Ayurveda and Tibetan Medicine. In 1995, Taxus wallichiana was listed in Appendix II of CITES. Its legal status is that it has been included in the Red Data Book.

15. India is a party to the Ramsar Convention and has declared many areas as Ramsar Sites. Which of the following statements best describes as to how we should maintain these sites in the context of this Convention?
(a) Keep all the sites completely inaccessible to man so that they will not be exploited
(b) Conserve all the sites through ecosystem approach and permit tourism and recreation only
(c) Conserve all the sites through ecosystem approach for a period without any exploitation, with specific criteria and specific period for each site, and then allow sustainable use of then by future generations.
(d) Conserve all the sites through ecosystem approach and allow their simultaneous sustainable use
Correct Answer: (d)
Explanation: The Ramsar Convention (The Convention on Wetlands of International Importance, especially as Waterfowl Habitat) is an international treaty for the conservation and sustainable utilization of wetlands, i.e., to stem the progressive encroachment on an loss of wetlands now and in the future, recognizing the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value. Ramsar Convention calls for sustainable use of preserved sites in such a way that people living there shall not be deprived and the resources are also maintained for present and future use.

16. Which one of the following is not essentially a species of the Himalayan vegetation? (2008)
(a) Juniper (b) Mahogany
(c) Silver fir (d) Spruce
Correct Answer: (b)

17. Consider the following statements: (2005)

1. The forest cover in India constitutes around 20% of its geographical area. Out of the total forest cover, dense forest constitutes around40%.
2. The National Forestry Action Programme aims at bringing one-third of the area of Indian under tree/ forest cover.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

Correct Answer: (b)

18. Amongst the following Indian States which one has the minimum total forest cover? (2004)

(a) Sikkim (b) Goa
(c) Haryana (d) Kerala

Correct Answer: (c)

19. **Assertion (A):** Unlike temperate forests, the tropical rain forests, if cleared, can yield productive farmland that can support intensive agriculture for several years even without chemical fertilizers. **Reason (R):** The primary productivity of the tropical rain forest is very high when compared to that of temperate forests. (2003)

(a) Both A and R are true, and R is the correct explanation of A
(b) Both A and R are true, but R is not the correct explanation of A
(c) A is true, but R is false
(d) A is false, but R is true

Correct Answer: (d)

Explanation: A is wrong R is correct. In tropical rainforests because of the rainfall throughout the year, leaching of minerals occur. Due to high temperatures bacterial activity is enormous, there by humus content in the soil decreases. To raise crops in this region requires application of chemical fertilizers.

20. Which one among the following covers the highest percentage of forest area in the world? (2003)

(a) Temperate Coniferous forests (b) Temperature Deciduous forests
(c) Tropical Monsoon forests (d) Tropical Rain forests

Correct Answer: (a)

21. Open stunted trees having long roots and sharp thorns or spines are commonly found in: (2002)

(a) Eastern Orissa (b) North-Eastern Tamil Nadu
(c) Siwaliks and Terai region (d) Western Andhra Pradesh

Correct Answer: (d)

Explanation: The tropical semi-desert type merges into the tropical thorn forests when natural vegetation consists of open stunted forest with widely scattered trees and bushes and having long roots and sharp thorns. Eastern Rajasthan, South-west Punjab and Haryana, Bundelkhand region of Madhya Pradesh, Southern Karnataka and adjoining Andhra Pradesh have this type of vegetation.

22. Match List I with List II and select the correct answer using the codes given below the lists: (2002)

List I (Mangrove)	**List II (State)**
A. Achra Ratnagiri	1. Karnataka
B. Coondapur	2. Kerala
C. Pichavaram	3. Andhra Pradesh
D. Vembanad	4. Maharashtra
5. Tamil Nadu	

A B C D
(a) 2 1 5 4
(b) 4 5 3 2
(c) 2 5 3 4
(d) 4 1 5 2

Correct Answer: (d)

23. Consider the following ecosystems: (2002)

1. Taiga
2. Tropical evergreen
3. Tropical deciduous
4. Tundra

The correct sequence in decreasing order of the albedo values of these ecosystems is

(a) 1, 4, 3, 2 (b) 4, 1, 2, 3 (c) 4, 1, 3, 2 (d) 1, 4, 2, 3

Correct Answer: (c)

Explanation: The earth's average albedo is 34%. But it varies according to the texture and colour of the surface. For fresh snow, the albedo is 85%, for forests, it is 5-10%. Accordingly, the order is Tundra – Taiga – Tropical evergreen – Tropical deciduous.

24. With reference to 'Eco-Sensitive Zones', which of the following statements is/are correct?

1. Eco-Sensitive Zones are the areas that are declared under the Wildlife (Protection) Act, 1972.
2. The purpose of the declaration of Eco-Sensitive Zones is to prohibit all kinds of human activities, in those zones except agriculture.

Select the correct answer using the code given below. (2014)

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Correct Answer: (d)

WETLANDS

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4. WETLANDS

4.1. INTRODUCTION

Wetlands are defined as lands transitional between terrestrial and aquatic eco-systems where the water table is usually at or near the surface or the land is covered by shallow water. The land area is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem. The primary factor that distinguishes wetlands from other land forms or water bodies is the characteristic vegetation of aquatic plants, adapted to the unique hydric soil (saturated soil with anaerobic conditions).

Under the Ramsar International Wetland Conservation treaty, wetlands are defined as:

Article 1.1.: Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

Article 2.1.: Wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands.

4.2. CLASSIFICATION

There are several ways in which the wetland classification is done. According to Ramsar Convention, three major classes are identified:

- Marine/Coastal Wetlands
- Inland Wetlands
- Human-made Wetlands

These are subdivided by the type of water: fresh / saline / brackish / alkaline; further may be subdivided based on whether they are permanent or temporary.

Examples:

Wetland Type	Subtype	Example
Marine/Coastal	Saline	Shallow waters less than 6 m deep, Coral Reefs Sand, shingle or pebble shores
	Saline or Brackish	Intertidal marshes and forested wetlands, Mangroves, coastal lagoons, estuarine waters, Karst or other subterranean hydrological systems (maybe fresh water also)
Inland	Fresh water	Flowing water like rivers, streams; Inland river deltas; Freshwater springs, oasis Seasonal rivers and streams; Lakes
	Saline, Brackish or Alkaline	Bogs, Peats, Marshes
Human Made		Aquaculture ponds, irrigation channels, irrigated fields, seasonally flooded agricultural land, salt exploitation sites, Water storage areas and dams

4.3. THE FOUR MAIN TYPES OF WETLANDS

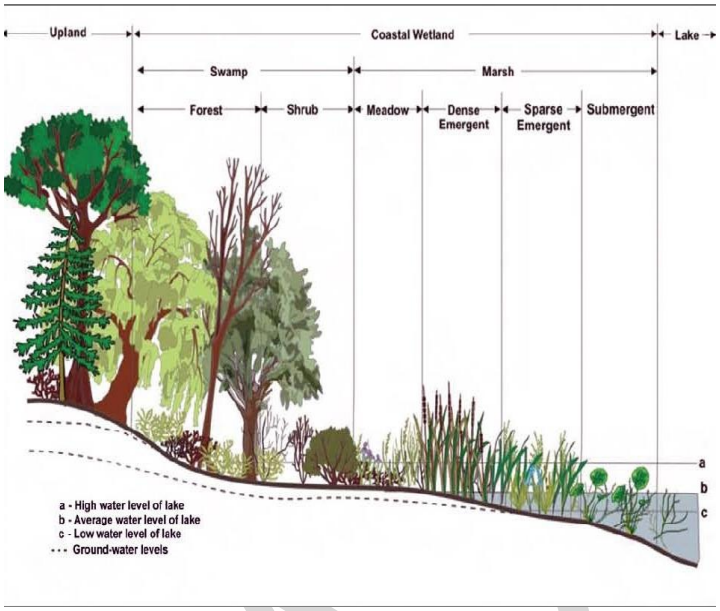
4.3.1. MARSH

It is a wetland that is dominated by herbaceous rather than woody plant species. Marshes can often be found at the edges of lakes and streams, where they form a transition between the aquatic and terrestrial ecosystems. They are often dominated by grasses, rushes or reeds. If woody plants are present they tend to be low-growing shrubs.

4.3.2. SWAMP

A swamp is a wetland that is forested. Swamps are characterized by slow-moving to stagnant waters. They are usually associated with adjacent rivers or lakes. The water of a swamp may be fresh water, brackish water or seawater. Some of the world's largest swamps are found along major rivers such as the Amazon, the Mississippi,

and the Congo. Peat swamp forests are swamp forests where waterlogged soils prevent woody debris from fully decomposing, which over time creates a thick layer of acidic peat.



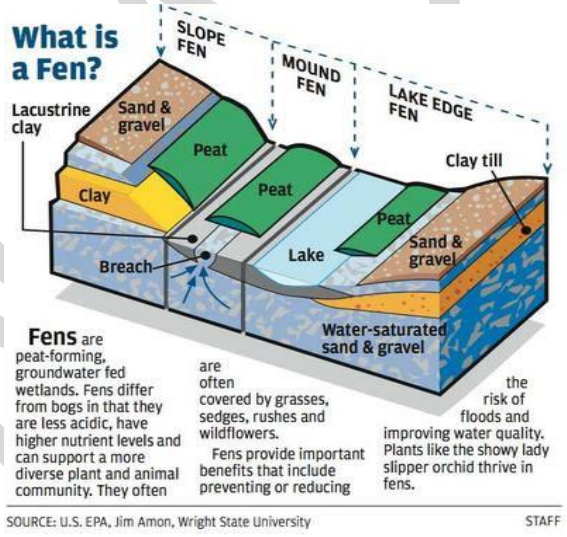
Mire- A mire is a wetland without forest cover, dominated by peat-forming plants. There are two types of mires:-

4.3.3. BOG

A Bog is a mire that accumulates peat. A Bog is dome shaped landform, is higher than the surrounding landscape, and obtains most of its water from rainfall. The gradual accumulation of decayed plant material in a bog functions as a carbon sink. The characteristic is acidic surface water, low in nutrients. These are the features of cold, temperate boreal climate of Northern Hemisphere.

4.3.4. FEN

The difference with Bog is that a Fen is served by both groundwater and rainfall and is therefore, is slightly acidic, neutral or alkaline. It is relatively rich in minerals. It is located on a slope, flat or a depression. They are also features of cold climates such as in Western Europe.



4.4. ECOLOGY OF WETLANDS

Despite their great range in size and other features, wetlands share specific characteristics. These can be structural (water, substrate, biota), or functional (nutrient cycling, water balance, organic production).

Wetlands are neither aquatic nor terrestrial. Wetlands have some of the same features as deep-water systems like species of algae, vertebrates, and invertebrates. Most wetlands share with terrestrial ecosystems a flora dominated by vascular plants, although the species composition of wetlands generally differs from that of uplands. Wetlands often are found at the interface of terrestrial ecosystems (such as upland forests and grasslands) and aquatic systems (such as lakes, rivers, and estuaries).

1. **Hydrology** - Hydrology controls (and is in turn affected by) the abiotic and biotic characteristics of wetlands. Abiotic characteristics such as soil colour, texture, and water quality depend on the distribution and movement of water. It also influences the structure and function of wetland ecosystems through its influence on species richness, productivity, rates of organic matter accumulation, and nutrient cycling. Sources of hydrological flows into wetlands are predominantly precipitation, surface water, and ground water. Water flows out of wetlands by evapotranspiration, surface runoff, and sub-surface water outflow. Hydrodynamics (the movement of water through and from a wetland) affects hydroperiods (temporal fluctuations in water levels) by controlling the water balance and water storage within a wetland.

   Hydrology may restrict species richness in areas subject to long-term flooding while enhancing it in areas with variable hydroperiods. Similarly, productivity is typically lower in permanently flooded, stagnant wetlands than in slow-flowing, seasonally flooded ones.

2. **Soil Acidity/Alkalinity –** Low mineral content yields fewer nutrients and a lower pH. Acidic conditions inhibit the ability of most plants to take up nutrients.
3. **Oxygen Availability -** The inundation or saturation of wetland soils by water leads to the formation of anaerobic conditions as oxygen is depleted faster than it can be replaced by diffusion.

4.5. WETLAND COMMUNITIES AND ECOSYSTEMS

Because of the predominance of water and anaerobic conditions in wetlands, the organisms living there, especially rooted plants, exhibit remarkable adaptations to deal with the stresses imposed by flooding. These adaptations, including pressurized gas flow, creation of oxidized root zones, and anaerobic respiration, allow wetland plants to remain productive under otherwise stressful conditions, making wetlands among the most productive ecosystems in the world. This high primary production, in turn, supports high rates of secondary production

Mangroves are an example of tropical coastal vegetation, which shows number of adaptations to wetland conditions. For a plant to survive in this environment it must tolerate broad ranges of salinity, temperature, and moisture, as well as a number of other key environmental factors — thus only a select few species make up the mangrove tree community. Some of the adaptations are:

- They are salt tolerant, also called **Halophytes**. They have a complex salt filtration systems and a complex root system to cope with salt water immersion and wave action. They can also store salts in cell vacuoles.
- Adapted to low oxygen (Anoxic) conditions – **Pneumatophores,** which are specialised root-like structures which stick out of the soil like straws for breathing. They also absorb gases like nitrogen directly and store them.
- **Lenticles** are pores in the bark which also help absorb air.
- **Buttress roots,** which are aerial extensions of lateral surface roots and form only in certain species. Buttress roots stabilize the tree, especially in shallow, saturated, nutrient poor soils.
- **Vivipary Germination –** Seeds germinate while being attached to the parent tree, unlike most other plants whose seeds germinate in the soil. Once matured, it is called **propagule,** it drops into the water which transports it. This is how survival of offspring is ensured.
- Limiting the water loss through restriction of opening of stomata.

It should be noted that a given Mangrove vegetation has only a small number of tree species (most common is *Rhizophora*), and that too show distinct zonation, but the overall biodiversity of the ecosystem is very high.

4.6. IMPORTANCE OF WETLANDS

While covering only 6% of the Earth's surface, wetlands provide a disproportionately high number of ecosystem services, in addition to maintaining biodiversity. For instance, wetlands also mitigate floods, protect coastal areas from storms, improve water quality, recharge groundwater aquifers, serve as sinks, sources, or transformers of materials, and produce food and goods for human use. Regional wetlands are integral parts of larger landscapes; their functions and values to the people in these landscapes depend on both their extent and their location. Each wetland thus is ecologically unique. Some important uses of wetlands:

- **Aquaculture:** Wetlands are used to harvest fish/aquatic animals for human consumption and pharmaceuticals.
- **Flood control:** they act as a barrier to absorb excess water.
- **Groundwater replenishment:** The surface water which is the water visibly seen in wetland systems only represents a portion of the overall water cycle which also includes atmospheric water and groundwater. Wetland systems are directly linked to groundwater and a crucial regulator of both the quantity and quality of water found below the ground.
- **Shoreline stabilisation and storm protection:** Tidal and inter-tidal wetland systems protect and stabilize coastal zones. Coral reefs and mangroves provide a protective barrier to coastal shoreline.
- **Nutrient retention:** Wetland vegetation up-take and store nutrients found in the surrounding soil and water.
- Sediment traps
- **Water purification:** Many wetland systems possess biofilters, hydrophytes, and organisms that in addition to nutrient up-take abilities have the capacity to remove toxic substances that have come from pesticides, industrial discharges, and mining activities.
- **Reservoirs of biodiversity**
- **Wetland products:** Apart from aquaculture products, wetland systems naturally produce an array of vegetation and other ecological products that can harvested for personal and commercial use. Some important products: rice, sago palm, nipa palm, honey from mangroves, Fuel wood, Salt (produced by

evaporating seawater), Animal fodder, Traditional medicines (e.g. from mangrove bark), Fibres for textiles, Dyes and tannins.

- **Cultural values**
- **Recreation and tourism**
- **Climate change mitigation and adaptation:** Wetlands perform two important functions in relation to climate change. They have mitigation effects through their ability to sink carbon, and adaptation effects through their ability to store and regulate water. However, coastal wetlands, such as tropical mangroves and temperate salt marshes are also emitters of nitrous oxide (N_2O). In Southeast Asia, peatswamp forests and soils are source of CO2. Rice fields are source of methane.

4.7. WETLANDS AS RESERVOIR OF BIODIVERSITY

Wetlands are considered the most biologically diverse of all ecosystems, serving as home to a wide range of plant and animal life.

- ***Flora:*** There are several hundred plant species wetlands, including mosses, herbs, ferns, rushes, sedges, grasses (seagrass and eelgrass), reeds, shrubs and trees. Wetland plants are adapted to a wetland's hydrological regime. Some plants require wetting and drying cycles to reproduce, such as river red gums. Other plants require a constant supply of water to survive, such as aquatic plants like sedges and rushes, marine plants like seagrasses, and cool climate plants like mosses.
- ***Fauna:***
  - Fish are more dependent on wetland ecosystems than any other type of habitat. Tropical fish species need mangroves for critical hatchery and nursery grounds and the coral reef system for food.
  - Amphibians such as frogs need both terrestrial and aquatic habitats in which to reproduce and feed.
  - Reptiles such as alligators and crocodiles are common reptilian species.
  - Mammals such as the beaver, swamp rabbit, and panther.
  - Monotremes (Mammals that lay eggs) such as platypus endemic to Australia.
  - Insects and invertebrates total more than half of the 100,000 known animal species in wetlands.
  - **Birds:** Wetlands are habitat to birds like waterfowl (ducks, geese, and swans), grebes, pelicans, etc. They are also important as resting sites for migratory birds. Aquatic vegetation is a valuable source of food, especially for waterfowl in India. In the winter, migratory waterfowl search the sediment for nutritious seeds, roots and tubers. Resident waterfowl may feed on different species of aquatic vegetation year-round.
- **Algae:** Algae occur naturally in habitats such as inland lakes, inter-tidal zones, and damp soil and provide a dedicated food source for animals, fish, and invertebrates.

4.8. WETLAND DISTRIBUTION IN INDIA

Natural wetlands in India consists of the high-altitude Himalayan lakes, followed by wetlands situated in the flood plains of the major river systems, saline and temporary wetlands of the arid and semi-arid regions, coastal wetlands such as lagoons, backwaters and estuaries, mangrove swamps, coral reefs and marine wetlands, and so on. With the exception of bogs, fens and typical salt marshes, Indian wetlands cover the whole range of the ecosystem types found. In addition to the various types of natural wetlands, a large number of man-made wetlands also contribute to the faunal and floral diversity. These man-made wetlands, which have resulted from the needs of irrigation, water supply, electricity, fisheries and flood control, are substantial in number. The various reservoirs, shallow ponds and numerous tanks support wetland biodiversity and add to the country's wetland wealth. It is estimated that freshwater wetlands alone support 20 per cent of the known range of biodiversity in India.

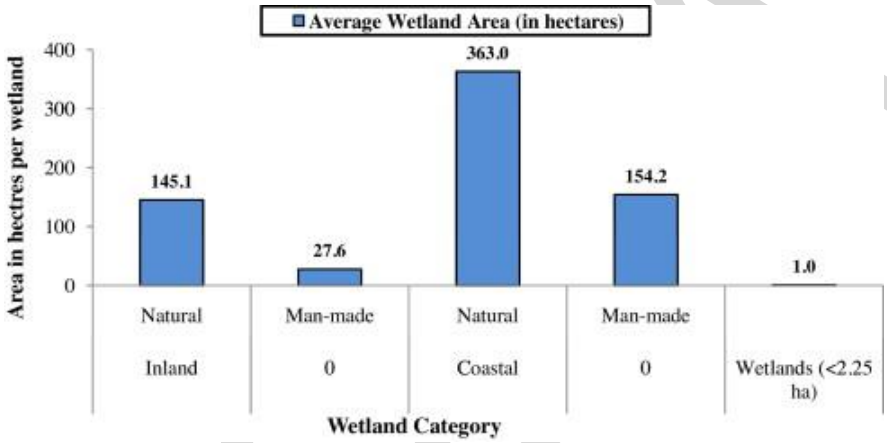
The majority of the inland wetlands are directly or indirectly dependent on the major rivers like Ganga, Bhramaputra, Narmada, Godavari, Krishna, Kaveri and Tapti. They occur in the hot arid regions of Gujarat and Rajasthan, the deltaic regions of the east and west coasts, highlands of central India, wet humid zones of south peninsular India and the Andaman and Nicobar and Lakshadweep Islands.

Wetlands in India account for 4.7% of the total geographical area of the country. Out of this, area under inland wetlands accounts for 69%, coastal wetlands 27%, and other wetlands (smaller than 2.25 ha) 4%. In terms of average area under each type of wetland, natural coastal wetlands have the largest area. In terms of the proportion of the geographical area, Gujarat has the highest proportion (17.5%) and Mizoram has the lowest

proportion (0.66%) of the area under wetlands. Among Union Territories in India, Lakshadweep has the highest proportion (around 96%) and Chandigarh has the least proportion (3%) of geographical area under wetlands.

Indian wetlands are grouped as:

- **Himalayan wetlands:** Ladakh and Zanskar (Pangong Tso, Tso Morad, Chantau, Noorichan, Chushul and Hanlay marshes); Kashmir Valley (Dal, Anchar, Wular, Haigam, Malgam, Haukersar and Kranchu lakes); Central Himalayas (Nainital, Bhimtal and Naukuchital); Eastern Himalayas (Numerous wetlands in Sikkim, Assam, Arunachal Pradesh, Meghalaya, Nagaland and Manipur, Beels in the Brahmaputra and Barak valley)
- **Indo-Gangetic wetlands:** The Indo-Gangetic flood plain is the largest wetland system in India, extending from the river Indus in the west to Brahmaputra in the east. This includes the wetlands of the Himalayan terai and the Indo-Gangetic plains.
- **Coastal wetlands:** The vast intertidal areas, mangroves and lagoons along the 7500 km long coastline in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat; Mangrove forests of Sunderbans, Andaman and Nicobar Islands; Offshore coral reefs of Gulf of Kutch, Gulf of Mannar, Lakshwadeep and Andaman and Nicobar Islands.
- **Deccan:** A few natural wetlands, but innumerable small and large reservoirs and several water storage tanks in almost every village in the region.



Average area under different wetlands in India

4.9. THREAT TO WETLAND ECOSYSTEM

Wetlands are often described as kidneys of the landscape. Hydrological conditions can directly modify or change chemical and physical properties such as nutrient availability, degree of substrate anoxia, soil salinity, sediment properties, and pH. These modifications have a direct impact on the biotic response in the wetlands through changes in species composition and richness and in ecosystem productivity. The density of birds, in particular, is an accurate indication of the ecological health of a particular wetland.

Wetlands are one of the most threatened habitats of the world and face several anthropogenic pressures. The rapidly expanding human population, large-scale changes in land use/land covers, burgeoning development projects, industrialisation and improper use of watersheds have all caused a substantial decline of wetland resources of the country. The most significant threat has been from agriculture. Unsustainable levels of grazing and fishing activities have also resulted in degradation of wetlands.

Some seriously threatened wetlands in India are - Dal Lake, Loktak Lake, Wular Lake, Salt Lakes swamp, Harike Lake, Sunderbans, Southern Gulf of Kutch, Estuaries of the Karnataka coast, Gulf of Khambhat, Dipor Bheel, Wetlands in the Andaman and Nicobar Islands.

4.10. CAUSES OF WETLAND LOSS IN INDIA

Human Causes:

- Drainage for agriculture, forestry and mosquito control
- Dredging and stream channelization for navigation and food protection
- Filling for solid waste disposal, roads

- Conservation for aquaculture/mariculture
- Construction of dykes, dams and seawalls for flood control
- Discharge of pesticide, herbicide, nutrients from domestic sewage
- Mining of wetlands for peat, coal, gravel, phosphate and other minerals
- Ground water abstraction
- Sediment diversion by dams, deep channels
- Hydrological alterations by canals, roads and other structures
- Subsidence due to extraction of ground water oil, gas and other minerals

Natural Causes:

- Subsidence
- Sea level rise
- Drought
- Hurricane and other storms
- Erosion
- Biotic effects (natural as well as induced due to disturbances)

4.11. WETLAND PROTECTION EFFORTS IN INDIA

In India, wetlands continue to be seen in isolation and hardly figure in water resources management and development plans. Wetlands are not delineated under any specific administrative jurisdiction. The primary responsibility for the management of these ecosystems is in the hands of the Ministry of Environment and Forests. Though India is signatory to both Ramsar Convention on Wetlands and the Convention of Biological Diversity, there is no clear cut regulatory framework for conservation of wetlands. Some wetlands are protected after the formulation of the Wildlife Protection Act. Effective coordination between the different ministries, energy, industry, fisheries, revenue, agriculture, transport and water resources, is essential for the protection of these ecosystems.

Protection laws and government initiatives

Though there is no separate legal provision for wetland conservation in India, it is indirectly influenced by number of other legal instruments like - The Indian Fisheries Act – 1857, The Indian Forest Act – 1927, Wildlife (Protection) Act – 1972, Water (Prevention and Control of Pollution)Act – 1974, 1977, Environmental (Protection) Act – 1986, Coastal Zone Regulation Notification – 1991, etc.

Provisions under these acts range from protection of water quality and notification of ecologically sensitive areas to contributing towards conserving, maintaining, and augmenting the floral, faunal and avifaunal biodiversity of the country's aquatic bodies. However, the term wetland was not used specifically in any of these legal instruments.

1. National Wetland Conservation Programme (NWCP)

Government of India operationalized National Wetland Conservation Programme (NWCP) in closed collaboration with concerned State Government during the year 1985/86. Under the programme 115 wetlands have been identified till now by the Ministry which require urgent conservation and management initiatives (there are 26 Ramsar sites). The Scheme aims for conservation and wise use of wetlands in the country so as to prevent their further degradation. It has the following objectives:

- to lay down policy guidelines for conservation and management of wetlands in the country;
- to undertake intensive conservation measures in priority wetlands;
- to monitor implementation of the programme; and
- to prepare an inventory of Indian wetlands.

Conservation and management of wetlands is primarily vested with the State/UTs, who are in physical possession of the area. After identification of wetlands under the Scheme, the State/UTs are to submit long-term comprehensive Management Action Plans (MAPs) for a period of 3-5 years. Under the Scheme, Ministry also sponsor multidisciplinary research projects by academic/ managerial/ research institutions on various aspects of wetland conservation to supplement execution of MAP in more realistic manner.

In 1993, National Lake Conservation Plan (NLCP) was carved out of NWCP to focus on lakes particularly those located in urban and peri-urban areas which are subjected to anthropogenic pressures.

2. The National Environmental Policy 2006

recognized the importance of wetlands in providing numerous ecological services. The policy accepted that there is no formal system of wetland regulation in the country outside the international commitments made in respect of Ramsar sites and thus there is a need of legally enforceable regulatory mechanism for identified valuable wetlands, to prevent their degradation and enhance their conservation.

Based on the directives of National Environment Policy, 2006 and recommendations made by National Forest Commission, Central Government notified the **Wetlands (Conservation and Management) Rules, 2010.** Under it, Central Wetlands Regulatory Authority (CWRA) has been constituted. The rules put restrictions on the activities such as reclamation, setting up industries in vicinity, solid waste dumping, manufacture or storage of hazardous substances, discharge of untreated effluents, any permanent construction, etc. within the wetlands. It also regulates activities (which will not be permitted without the consent of the State government) such as hydraulic alterations, unsustainable grazing, harvesting of resources, releasing treated effluents, aquaculture, agriculture and dredging.

The wetlands included under it are: (1) wetlands selected under Ramsar Convention; (2) wetlands in ecologically sensitive and important areas; (3) wetlands recognized as UNESCO World Heritage site; (4) high altitude wetlands (at or above an elevation of 2500 m with an area equal to or greater than five hectares); (5) wetland complexes below an elevation of 2500 m with an area equal to or greater than 500 ha; and (6) any other wetland identified by the Authority (Wetlands Rules, 2010).

Criticism:

Despite the recent national legislation on wetland regulation, a majority of the wetlands continue to be ignored in the policy process. Also, rules do not recognize the traditional rights over the wetlands for livelihoods even as they seek to regulate such activities. Such regulation can in effect become prohibitive for livelihood activities. The rules limit the involvement of community and local stakeholder groups in the management of the wetlands. This goes against the Ramsar Convention which encourages active and informed participation of local and indigenous communities.

Given that only a small fraction of total wetlands have been taken up for conservation and growing threat to their ecosystem, it is essential that other ecologically important wetlands be identified and protected. Further, it is important to regulate large scale land use changes in the catchment area of wetlands and also prevent them from getting polluted in order to maintain their hydrological and ecological integrity. For achieving the second objective, an effective and proper water quality monitoring plan needs to be devised.

4.12. NATIONAL WETLAND PROTECTION STRATEGY

National wetland strategy should encompass:

- Conservation and collaborative management,
- Prevention of loss and promotion of restoration
- Sustainable management.

These include:

1. **Protection:** The primary necessity today is to protect the existing wetlands. There are thousands of wetlands that are biologically and economically important but have no legal status.
2. **Planning, Managing and Monitoring:** Wetlands that come under the Protected Area Network have management plans but others do not. It is important for various stakeholders along with the local community and the corporate sector to come together for an effective management plan. Active monitoring of these wetland systems over a period of time is essential.
3. **Comprehensive Inventory:** There has been no comprehensive inventory of all the Indian wetlands. The inventory should involve the flora, fauna, and biodiversity along with wetland direct and indirect values. It should take into account the various stakeholders in the community too.
4. **Legislation:** Although several laws protect wetlands there is no special legislation pertaining specially to these ecosystems. Environment Impact Assessment is needed for major development projects and highlighting threats to wetlands need must be included and appropriate measures to be formulated.

5. **Coordinated Approach:** Because Wetlands are common property with multi-purpose utility, their protection and management also need to be a common responsibility. An appropriate forum for resolving the conflict on wetland issues has to be set up.
6. **Research:** There is a necessity for research in the formulation of a national strategy to understand the dynamics of these ecosystems. This could be useful for the planners to formulate strategies for the mitigation of pollution. The scientific knowledge will help the planners in understanding the economic values and benefits, which in turn will help in setting priorities and, focusing the planning process.
7. **Building Awareness:** For achieving any sustainable success in the protection of these wetlands, awareness among the general public, educational and corporate institutions must be created. The policy makers at various levels, along with site managers, need to be educated. Because the country's wetlands are shared, the bi-lateral cooperation in the resource management needs to be enhanced.

Research Method

Remote sensing data in combination with Geographic Information System (GIS) methods are effective tools for wetland conservation and management. The application encompasses water resource assessment, hydrological modelling, flood management, reservoir capacity surveys, assessment and monitoring of the environmental impacts of water resources projects and water quality mapping and monitoring.

Conclusion

India being a mega-diversity country, so far managed to delineate a mere 26 sites to date. There is obviously much ground to be covered in our conservation efforts for wetlands. In addition, a paradigm shift in our conservation ethic is also a strong need of the hour. This shift is due to the very nature of the resource being conserved and protected. Because wetlands are a common property resource, it is an uphill task to protect or conserve the ecosystems unless the principal stakeholders are involved in the process. The dynamic nature of wetlands necessitates the widespread and consistent use of satellite-based remote sensors and low-cost, affordable GIS tools for effective management and monitoring.

- The country with the highest number of Sites is the United Kingdom with 170, and the country with the greatest area of listed wetlands is Bolivia, with over 140,000 square kilometres.
- Most recent COP12 was held in Punta del Este, Uruguay in 2015. COP13 will take place in Dubai, United Arab Emirates, in 2018.
- The Millennium Development Goals (MDGs) called for different sectors to join forces to secure wetland environments in the context of sustainable development and improving human wellbeing.
- Wetlands occur naturally on every continent except Antarctica, the largest including the Amazon River basin, the West Siberian Plain, and the Pantanal in South America.
- Latest wetland added in Ramsar list is Nalsarovar Bird Sanctuary in Gujarat.

4.13. RAMSAR CONVENTION ON WETLAND

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 169 Contracting Parties to the Convention, with 2,234 wetland sites, totalling 215 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance. Ramsar Convention is the only global environment treaty dealing with a particular ecosystem.

The Ramsar Convention on Wetlands was developed as a means to call international attention to the rate at which wetland habitats were disappearing, in part due to a lack of understanding of their important functions, values, goods and services. Governments that join the Convention are **expressing their willingness** to make a commitment to helping to reverse that history of wetland loss and degradation.

In addition, many wetlands are international systems lying across the boundaries of two or more countries, or are part of river basins that include more than one country. The health of these and other wetlands is dependent upon the quality and quantity of the trans-boundary water supply from rivers, streams, lakes, or underground aquifers. This requires framework for international discussion and cooperation toward mutual benefits.

Major obligations of countries which are party to the Convention are:

- Designate wetlands for inclusion in the List of Wetlands of International Importance.
- Promote, as far as possible, the wise use of wetlands in their territory.
- Promote international cooperation especially with regard to trans-boundary wetlands, shared water systems, and shared species.

- Create wetland reserves.

Criteria for representative or unique wetlands

A wetland is identified as being of international importance if it meets the criteria that were approved under Montreux (Switzerland) Record of the Ramsar Convention. Some of these are:

- Sites containing representative, rare or unique wetland types
- A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
- Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
- Regularly supports 20,000 or more waterbirds.
- Supports a significant proportion of indigenous fish subspecies and contributes to global biological diversity.
- Important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
- Regularly supports 1% of the individuals in a population of one species or subspecies of wetland dependent non-avian animal species.

Ramsar Sites in India

The list of Ramsar sites in India is as follows:

S. N.	Name of Site	State Location	Date of Declaration	Area (in sq.km.)
1	Asthamudi Wetland	Kerala	19.8.2002	1860
2	Bhitarkanika Mangroves	Orissa	19.8.2002	525
3	Bhoj Wetlands	Madhya Pradesh	19.8.2002	31
4	Chandertal Wetland	Himachal Pradesh	8.11.2005	38.56
5	Chilka Lake	Orissa	1.10.1981	1140
6	Deepor Beel	Assam	19.8.2002	4.14
7	East Calcutta Wetlands	West Bengal	19.8.2002	378
8	Harike Lake	Punjab	23.3.1990	86
9	Hokera Wetland	Jammu and Kashmir	8.11.2005	13.75
10	Kanjli Lake	Punjab	22.1.2002	14.84
11	Keoladeo Ghana NP	Rajasthan	1.10.1981	28.73
12	Kolleru Lake	Andhra Pradesh	19.8.2002	673
13	Loktak Lake	Manipur	23.3.1990	945
14	Nalsarovar Bird Sanctuary	Gujarat	24/09/12	120
15	Point Calimere	Tamil Nadu	19.8.2002	17.26
16	Pong Dam Lake	Himachal Pradesh	19.8.2002	307.29
17	Renuka Wetland	Himachal Pradesh	8.11.2005	Not Available
18	Ropar Lake	Punjab	22.1.2002	41.36
19	Rudrasagar Lake	Tripura	8.11.2005	2.40
20	Sambhar Lake	Rajasthan	23.3.1990	736
21	Sasthamkotta Lake	Kerala	19.8.2002	11.3
22	Surinsar-Mansar Lakes	Jammu and Kashmir	8.11.2005	3.50
23	Tsomoriri Lake	Jammu and Kashmir	19.8.2002	120
24	Vembanad Kol Wetland	Kerala	19.8.2002	4583
25	Upper Ganga River (Brijghat to Narora Stretch)	Uttar Pradesh	8.11.2005	265.90
26	Wular Lake	Jammu & Kashmir	23.3.1990	173

Montreux Record

It is a register of wetland sites on the list of wetlands of international importance where changes in ecological character have occurred or are occurring, or are likely to occur as a result of technological developments, pollution or other human interference. It is maintained as part of Ramsar List.

Currently, two wetlands of India are in Montreux record viz. Keoladeo National Park, Rajasthan and Loktak Lake, Manipur. Further, Chilka Lake was placed in the record but was later removed from it.

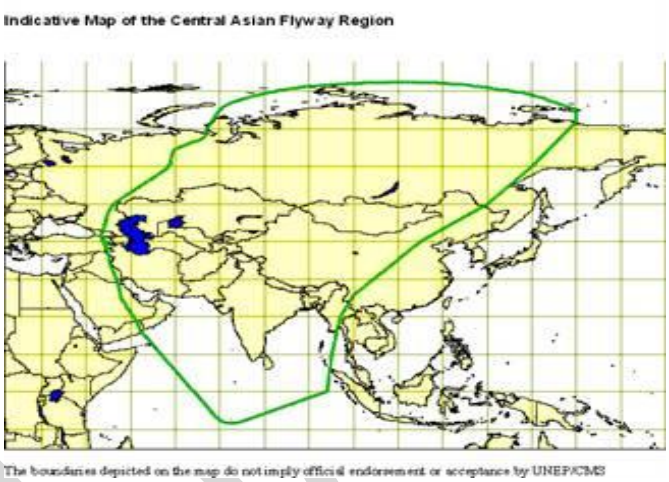
Salim Ali Centre for Ornithology and Natural History (SACON)

The necessity for the study and conservation of birds in particular, and wildlife and biodiversity in general, prompted the Ministry of Environment and Forests, Government of India to establish the Salim Ali Centre for

Ornithology & Natural History as a public - NGO partnership between the MoEF, and the Bombay Natural History Society (BNHS) under the Centre of Excellence Scheme. It is a Society registered in 1990 under the Societies registration Act, with the object of establishing and developing a Centre of Excellence to assist, institute, conduct and promote scientific research in ornithology, and of species, habitats and ecosystems with and within which avifauna coexist, and developing scientific solutions to species, habitat and landscape conservation problems that are sensitive to the socio-economic realities and aspirations of the people.

4.14. WETLANDS INTERNATIONAL

It is a global organisation that works to sustain and restore wetlands and their resources for people and biodiversity. It is an independent, not-for-profit, global organisation, supported by government and NGO membership from around the world.



Wetlands International has been the driving force behind the development of the Central Asian Flyway initiative. The Central Asian Flyway covers the areas used by species of birds with the main migratory routes through Central Asia. It has also been referred to as "Central Asian-Indian Flyway" or as "Central Asian-South Asian Flyway". As such, the area extends from the Arctic Ocean in the North until the Indian Ocean in the South (including islands in that region) and thus covers territories of 30 Asian and East European countries. It overlaps with the African Eurasian flyway in the West, and the East Asian flyways in the East.

ENVIRONMENTAL CHANGE: CLIMATE CHANGE AND POLLUTION

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5. ENVIRONMENTAL CHANGE: CLIMATE CHANGE AND POLLUTION

Introduction

Environmental change is usually defined as a change or disturbance of the environment most often caused by human influences and natural ecological processes. Environmental change does not only encompass physical changes, but also biotic changes in the ecosystem, such as those caused by infestation of invasive species.

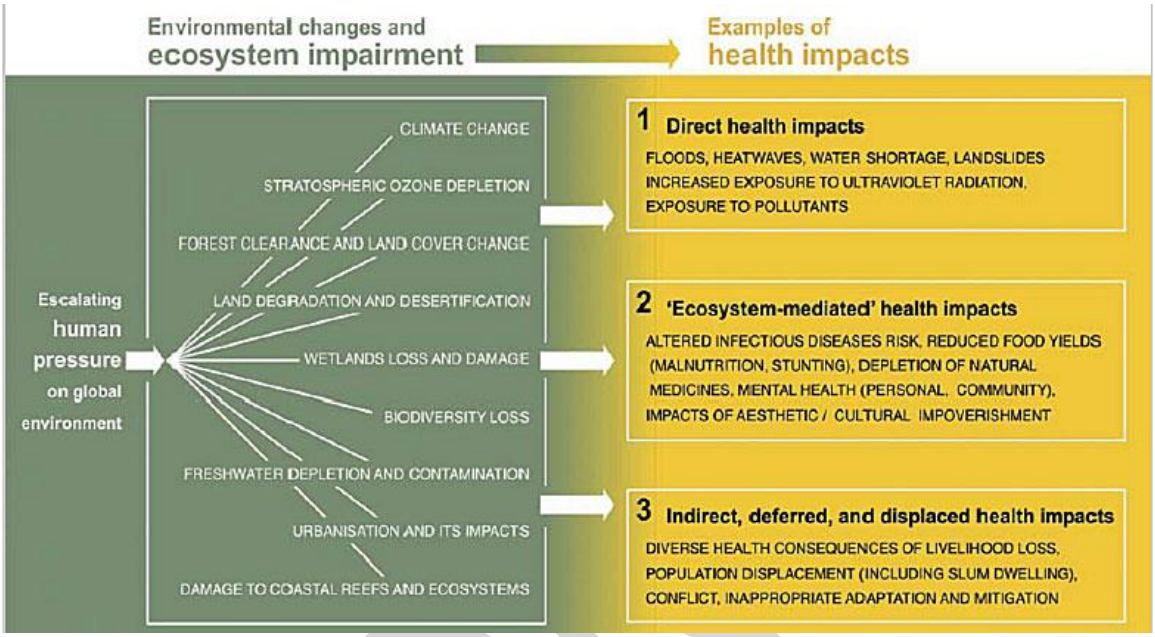


Figure depicting environmental change and its impact

As depicted in the figure above environmental change can be of the following types:

5.1. CLIMATE CHANGE

Climate change is a long-term shift in weather conditions identified by changes in temperature, precipitation, winds, and other indicators. Climate change can involve both changes in average conditions and changes in variability, including, for example, frequency of extreme events.

When we speak about climate change, most people think about global warming. And if we speak about global warming, most of us think about the greenhouse effect. The greenhouse effect is actually a naturally occurring process which has been accelerated by human activity.

5.1.1. CAUSES OF CLIMATE CHANGE

Any factor that causes a sustained change to the amount of incoming energy or the amount of outgoing energy can lead to climate change. Different factors operate on different time scales, and not all of those factors that have been responsible for changes in earth's climate in the distant past are relevant to contemporary climate change. Factors that cause climate change can be divided into **two** categories - those related to natural processes and those related to human activity.

Natural Causes

The Earth's climate can be affected by natural factors that are external to the climate system, such as changes in **volcanic activity, solar output, and the Earth's orbit around the Sun**. Of these, the **two factors relevant on timescales of contemporary climate change are changes in volcanic activity and changes in solar radiation.** In terms of the Earth's energy balance, these factors primarily influence the amount of incoming energy.

Volcanic eruptions are episodic and have relatively short-term effects on climate. Changes in solar irradiance have contributed to climate trends over the past century but since the Industrial Revolution, the effect of additions of greenhouse gases to the atmosphere has been about ten times that of changes in the Sun's output.

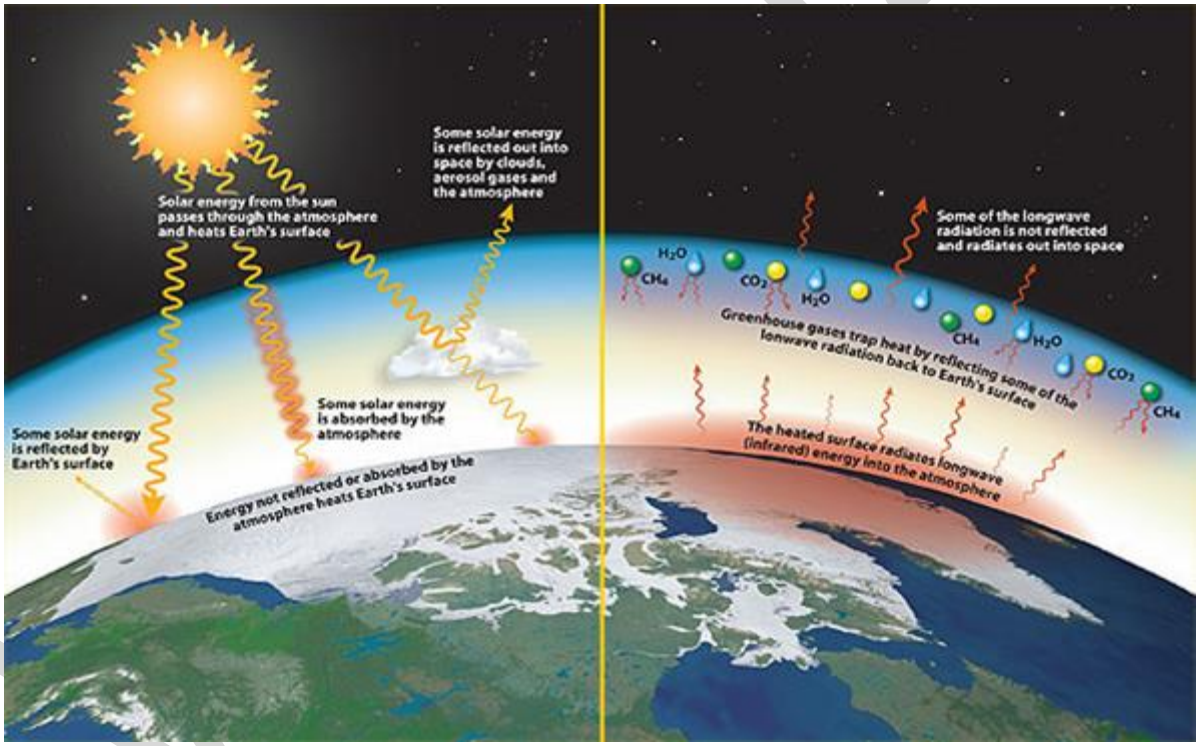
Human Causes

- **Increase in the level of greenhouse gases** has led to considerable heating of Earth leading to global warming. During the past century, the temperature of Earth has increased by **0.8° Celsius**, most of it during the last three decades.
- **Deforestation** is the conversion of forested areas to non-forested ones. A number of human activities contribute to it. One of the major reasons is the conversion of forest to agricultural land so as to feed the growing human population. Trees are axed for timber, firewood, cattle ranching and for several other purposes. Since forests are major consumers of Carbon Dioxide, therefore deforestation is a major contributor to global warming.

5.1.2. GREENHOUSE EFFECT AND GLOBAL WARMING

The term 'Greenhouse effect' has been derived from a phenomenon that occurs in a greenhouse. In a greenhouse the glass panel lets the light in, but does not allow heat to escape. Therefore, the greenhouse warms up, very much like inside a car that has been parked in the sun for a few hours.

The greenhouse effect is a naturally occurring phenomenon that is responsible for heating of Earth's surface and atmosphere. Sunlight warms the surface of the Earth. Since the earth cannot store this heat forever, the warm Earth sends energy back into space. The sunlight which hits the Earth's surface is made up of **high energy ultra-violet and visible radiation.** The energy emitted from the surface of the Earth is **infra-red or 'longwave radiation' and is less energetic than sunlight**.



Particles and gases in the air absorb infrared heat radiation. The gases are called **greenhouse gases**. They let the sunlight in, but they don't let the heat radiation from Earth back out into space. They trap the heat near the ground. The greenhouse effect is very important for life on Earth. The average temperature of the Earth is 15 degree Celsius and if there were no greenhouse gases in the air, the average temperature of the Earth would be about 30 degree Celsius lower.

We need a **natural greenhouse effect**. But by putting more and more greenhouse gases into the air, humans have **enhanced** the natural greenhouse effect and are making the Earth warmer. It's not the natural greenhouse effect which is causing global warming, it's the additional greenhouse effect caused by humans which is causing the main culprit.

Greenhouse Gases and their Contribution

Greenhouse gases (GHGs) warm the Earth by absorbing energy and slowing the rate at which the energy escapes to space; they act like a blanket insulating the Earth. Different GHGs can have different effects on the Earth's

warming. Two key ways in which these gases differ from each other are their ability to absorb energy (their "radiative efficiency"), and how long they stay in the atmosphere (also known as their "lifetime"). The most important greenhouse gas is **water vapour** (which accounts for about 60% of the greenhouse effect) but the concentrations of water vapour in the atmosphere have changed much over the past few centuries. So it is unlikely that water vapour is responsible for the observed warming of our planet.

However, human activity has dramatically increased the concentration of **carbon dioxide** in the atmosphere. Carbon dioxide is the most important greenhouse gas in the atmosphere, contributing about 60% of the greenhouse effect (if water vapour is not counted). **Methane** is the second most important greenhouse gas in the atmosphere, contributing about 20% of the greenhouse effect. Concentrations of methane and ozone, which are also strong greenhouse gases, have also increased dramatically since the industrial revolution.

The **Global Warming Potential (GWP)** was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO2). The larger the GWP, the more that a given gas warms the Earth compared to CO2 over that time period. The time period usually used for GWPs is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases (e.g., to compile a national GHG inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gases. CO2, by definition, has a GWP of 1 regardless of the time period used, because it is the gas being used as the reference.

Methane (CH4) is estimated to have a GWP of 28–36 over 100 years. CH4 emitted today lasts about a decade on average, which is much less time than CO2. But CH4 also absorbs much more energy than CO2. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. The CH4 GWP also accounts for some indirect effects, such as the fact that CH4 is a precursor to ozone, and ozone is itself a GHG.

Table: Natural and anthropogenic greenhouse gases and their lifetime in the atmosphere

GHGs	Lifetime in atmosphere (years)	Sources		Sink	GW Potential over-		share
		Natural	Anthropogenic		20 Years	100 years	
CO_2	Variable	---	Burning fossil fuels, deforestation, aerobic fermentation of solid waste and wastewater	Oceans, Forests	1	1	60%
CH_4	12	Wetlands, Oceans	Animal waste, paddy fields, burning fossil fuels, anaerobic fermentation of solid waste & wastewater	Earth bacteria and chemical reactions in the atmosphere	56	21	20%
N_2O	120	Microbial processes in oceans' waters and natural soil	Fertilized soil, biomass and fossil fuel burning	Soil Photochemical reactions in the atmosphere	280	310	6%
O_3		Complex photochemical reactions in the atmosphere	---	Reaction with free radicals in the atmosphere and complex photochemical reactions	Several hours to days		
CFCs	45	---	Industrial activities, refrigerators, pesticides, artificial solvents, and foam products	Chemical reactions in ozone layer	7020	5350	14%
HFC-23	264				9100	11700	

CO2 Emission Worldwide

About a third of the world's Carbon Dioxide emissions come from Asia, Australia and Oceania and 28% comes from North America – almost 60% of the global CO2 emissions come from these two regions. However, even though both regions emit almost the same amount of CO2 per year, the causes are quite different. About 3.9 billion people live in Asia, Australia and Oceania, that's 61% of the world population, whereas only about 323 million people live in North America (U.S.A. and Canada).

High CO2 emissions in Asia, Australia and Oceania are simply the result of the huge number of people living in the region, in North America it is the very high consumption of energy which is the cause.19.7 tonnes of CO2 are emitted per citizen in the USA, while in India it is only 1.1 tonnes. Such huge differences result from the different degree of economic development. Higher the standard of living in a country, higher is the energy consumption.

5.1.3. OZONE HOLE AND GLOBAL WARMING

Chlorofluorocarbons (CFCs) play a role in both global warming and ozone-hole formation. **In the troposphere, they act as greenhouse gases**. They absorb infra-red radiation coming from the surface of the Earth and, by trapping this heat close to the Earth they contribute to global warming. **In the stratosphere** they are broken down by high intensity ultra-violet radiation from the Sun into chlorine radicals and these **have the ability destroy ozone**. Other greenhouse gases, such as carbon dioxide and methane, do not have a comparable role in ozone depletion.

Since ozone prevents high intensity ultra-violet radiation from reaching the surface of the Earth and causes stratospheric warming, it can be assumed that formation of the ozone hole changes the total radiation budget of the Earth. This is, indeed, the case. **However, ozone depletion and the formation of the polar ozone holes don't lead to a further warming of the troposphere, but to a slight cooling.** It can be discussed as under:

1. Absorption of ultra-violet radiation by ozone molecules causes warming in the stratosphere. Some of this heat emitted in the stratosphere is transferred to the troposphere causing slight tropospheric warming as well. This warming gets lessened due to formation of ozone hole.
2. In the lower stratosphere, ozone can still act as a greenhouse gas and absorb infra-red radiation coming from the Earth's surface. So absorption of both ultra-violet and infra-red radiation by ozone leads to a warming of the upper troposphere. If ozone levels decrease, the upper troposphere will, therefore, get cooler.
3. Backscattering of solar radiation is particularly strong over the Antarctic where the strongest ozone depletion occurs. This is because the snow and ice covered ground has a very high albedo. Because of this high backscattering, only a small fraction of the extra ultra-violet radiation that enters the troposphere from ozone loss causes heating.

Overall, the cooling effect of ozone loss is the highest and decreases in ozone levels cause cooling not only in the stratosphere but also slight cooling in the troposphere.

5.1.4. FEEDBACK EFFECTS

When the Earth warms up, a large number of changes take place in the atmosphere, the oceans and on the land surface. Some of these changes can, in turn, affect the temperature. These are called feedback effects. Some of these feedback effects increase global warming, while others reduce it.

Feedback from water vapor

Water vapor is one of the most important feedback effects. A slight warming of the Earth due to more sunlight or an increased greenhouse effect, will lead to an increase in the amount of water vapor in the atmosphere. As water vapor is also a greenhouse gas, the extra water vapor will increase the greenhouse effect even more, leading to even greater warming. **Thus water vapor has an amplifying effect on global warming.**

Feedback from snow and ice cover

The feedback effects from ice and snow-covered surfaces are similar. When the climate is cold, there is a lot of ice and snow on Earth. These shiny surfaces reflect sunlight away from the ground and make it even colder. A

warmer climate means less ice and snow. **This leads to less reflection of solar radiation to outer space and increased warming.**

Feedback from clouds

When it gets warmer on Earth, the amount of water vapor in the atmosphere increases and more clouds may be formed. This can either increase or decrease warming, depending on what type of clouds they are. All clouds both cool the Earth by reflecting sunlight back into space and warm it up by absorbing heat from the surface in the same way that greenhouse gases do. **Thin cirrus clouds (which appear high up in the atmosphere when the weather is fine) generally have a warming effect. Low cumulus and stratus clouds, on the other hand, have a cooling effect.**

5.1.5. CLIMATE CHANGE AND OCEANS

Water has a very high specific heat capacity. This means that a lot of energy is needed to increase its temperature. As the Earth is 71% water, energy from the sun causes only small changes in the planet's temperature. This stops the Earth getting too hot or too cold and makes conditions possible for life. Heat is stored by the ocean in summer and released back to the atmosphere in winter. Oceans, therefore, moderate climate by reducing the temperature differences between seasons.

The largest carbon store on Earth is in sediments, both on land and in the oceans, and it is held mainly as calcium carbonate. The second biggest store is the deep ocean where carbon occurs mostly as dissolved carbonate and hydrogen carbonate ions. About a third of the carbon dioxide from fossil fuel burning is stored in the oceans and it enters by both physical and biological processes:

1. **Physical Process: Carbon dioxide dissolves more easily in cold water** than in warm water. It also dissolves more easily in seawater compared to pure water because seawater naturally contains carbonate ions.
   Cold waters sink to the deep ocean at high latitudes in the Southern Ocean and in the Nordic and Labrador Seas in the North Atlantic Ocean. These regions are therefore the major physical carbon dioxide removal areas of the ocean.
2. **Biological Process:** Carbon dioxide is also taken up by phytoplankton in photosynthesis and converted into plant material. Land plants and marine phytoplankton take up about the same amounts of carbon dioxide as each other but marine phytoplanktons grow much faster than land plants.

By burning fossil fuels, we are releasing carbon about a million times faster than natural biological cycles do. Forests and phytoplankton can't take up the carbon dioxide fast enough to keep up with the increases in emissions and atmospheric carbon dioxide levels have, therefore, risen dramatically over the past few decades.

Consequences of Global Warming on Oceans

Global warming is likely to have a number of effects on the ocean:

- **Carbon dioxide dissolves more easily in cold water than in warm water** so warmer temperatures will reduce the ability of the oceans to take up carbon dioxide and this will further enhance the greenhouse effect.
- Higher temperatures are also predicted to increase the input of freshwater into the high latitude oceans. Computer models suggest that this additional freshwater comes from increased rain at mid and high latitudes and from the melting of ice sheets.
- Ocean circulation is very sensitive to the amount of freshwater entering the system. Freshwater controls the density of seawater and therefore the ability of seawater to sink when it is cooled. If the water is too fresh, cooling won't make it dense enough to sink into the deep ocean. If water doesn't sink at high latitudes there is only wind driven forcing and therefore reduced water circulation around the oceans.
- Warmer temperatures also cause expansion of water and, along with the additional water from ice melt, will result in a rise in sea level and may cause flooding.
- Excess CO2 absorbed by the oceans will lead to formation of carbonic acid. This acidification will have detrimental effect shell forming creatures like the corals because it will reduce the ability of carbonate ions in the ocean needed to form shell.
- Will lead to migration of tropical marine creatures towards temperate areas thus disturbing the food chain, food availability and biodiversity of a region.

- Researchers have found that rising temperatures in the world's oceans will affect the development of the plankton on which most marine life feeds. It has been demonstrated that the increasing warmth caused by a changing climate will upset the natural cycles of carbon dioxide, nitrogen and phosphorous. This will affect the plankton, making it scarcer and so causing problems for fish and other species higher up the food chain.

5.1.6. AGRICULTURE AND GLOBAL WARMING

Intensive ploughing of agricultural land and deforestation are also ways to increase CO2 emissions. Soil contains a large amount of organic matter and is, therefore, also an important carbon store. When the soil is intensively ploughed, more oxygen can get into it. This extra oxygen increases the rate at which the organic matter is broken down into CO2.

Nitrous oxide (N2O) is produced biologically in soils, water and animal wastes. Over the last two centuries, human activities have increased N2O concentrations by 13%. The main sources of N2O are fossil fuel combustion, agricultural soil management, industry and the use of nitrogen based fertilizers.

The main sources of methane (natural gas) (CH4) are ruminant livestock (cows and sheep) and rice cultivation. Methane is produced by microscopic organisms which grow in anaerobic conditions. Anaerobic means that there is no oxygen present. Anaerobic conditions occur in waterlogged soils. Rice is grown in flooded fields so rice paddies are an ideal environment for these methane producing organisms to grow. **About a third of the total amount of methane in the atmosphere comes from agricultural sources.** Other natural sources of methane are coal and petroleum fields.

Agriculture can help to reduced greenhouse gas emissions by adopting practices that allow more CO2 to be stored in soils, crops and trees by ploughing less and slowing the rate of deforestation. More effective use of chemicals would lead to "cleaner" agriculture.

Climate Smart Agriculture

Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives:

- Sustainably increasing agricultural productivity and incomes
- Adapting and building resilience to climate change
- Reducing and/or removing greenhouse gas emissions, where possible.

CSA is an approach for developing agricultural strategies to secure sustainable food security under climate change. CSA provides the means to help stakeholders from local to national and international levels identify agricultural strategies suitable to their local conditions.

Developing the potential to increase the productivity and incomes from smallholder crop, livestock, fish and forest production systems will be the key to achieving global food security over the next twenty years. Climate change is expected to hit developing countries the hardest. Its effects include higher temperatures, changes in precipitation patterns, rising sea levels and more frequent extreme weather events. All of these pose risks for agriculture, food and water supplies. Resilience is therefore a predominant concern. Agriculture is a major source of greenhouse gas emissions. Mitigation can often be a significant co-benefit of actions to strengthen adaptation and enhance food security, and thus mitigation action compatible with national development priorities for agriculture is an important aspect of CSA.

Different elements of climate-smart agricultural systems include:

- Management of farms, crops, livestock, aquaculture and capture fisheries to balance near-term food security and livelihoods needs with priorities for adaptation and mitigation.
- Ecosystem and landscape management to conserve ecosystem services that are important for food security, agricultural development, adaptation and mitigation.
- Services for farmers and land managers to enable better management of climate risks/impacts and mitigation actions.
- Changes in the wider food system including demand-side measures and value chain interventions that enhance the benefits of CSA.

CSA is not a set of practices that can be universally applied, but rather an approach that involves different elements embedded in local contexts. CSA relates to actions both on-farm and beyond the farm, and incorporates technologies, policies, institutions and investment.

5.2. CONSEQUENCES OF CLIMATE CHANGE

Because the Earth's climate system is too large to undertake controlled experiments, scientists use mathematical models, known as **Global Circulation Models (GCMs)** to forecast climate trends over the coming decades. Major predictions are as below:

- Global climate models predict an increase in average global rainfall ranging from about 5 to 20% because a warmer atmosphere can hold more water vapour.
- High latitude regions (particularly the Polar Regions) and high elevations are likely to experience greater warming than the global mean warming, especially in winter.
- Winter time and night time minimum temperatures will continue to rise faster than average temperatures.
- The hydrological cycle is likely to further intensify, bringing more floods and more droughts.
- More winter precipitation is predicted to fall as rain, rather than snow. This will decrease snow pack and spring runoff, potentially worsening spring and summer droughts.
- Global warming will also affect sea level. There have been a range of estimates for sea level rise based on greenhouse gas emissions and temperature projections that affect the expansion of the water in the oceans and glacial melting. Recent estimates suggest that average sea levels will rise by around half a metre by 2100.
- The amount of oxygen dissolved in the oceans may decline, with adverse consequences for ocean life.
- Ocean acidification and climate change would impair a wide range of planktonic and shallow benthic marine organisms that use aragonite to make their shells or skeletons, such as corals and marine snails (pteropods), with significant impacts particularly in the Southern Ocean.
- Will lead to earlier leafing of trees and plants over many regions; movements of species to higher latitudes and altitudes in the Northern Hemisphere; changes in bird migrations in Europe, North America and Australia; and shifting of the oceans' plankton and fish from cold to warm-adapted communities.
- Climate change will impact agriculture and food production around the world due to: the effects of elevated CO_2 in the atmosphere, higher temperatures, altered precipitation and transpiration regimes, increased frequency of extreme events, and modified weed, pest, and pathogen pressure. In general, low-latitude areas are at most risk of having decreased crop yields.

5.2.1. METHODS TO HINDER CLIMATE CHANGE

People can slow down and eventually stop the climate change we have already started. The steps that can be helpful in doing so are:

- Burn less fossil fuel so that we emit less carbon dioxide. Technological improvements and lifestyle changes can reduce the amount of energy we use on transportation, heating, cooling, lighting, appliances that run on electricity, industrial production and so on. Alternative energy resources such as wind, solar, hydro, biomass and nuclear power should be exploited.
- Stop deforestation to prevent release of stored Carbon. Today deforestation is especially prevalent in developing countries, where forests are cut down for agriculture, industrialization and real estate.
- Garbage dumps (landfills) release methane (CH4) from rotting organic waste. By capturing this gas and using it as fuel, we get both heat and reduced emissions of greenhouse gases.
- Building an energy and resource efficient economy- especially the polluting agriculture and industrial sector.

5.2.2. CARBON SEQUESTRATION

Carbon sequestration is the process involved in **carbon capture** and the long-term storage of atmospheric CO2.

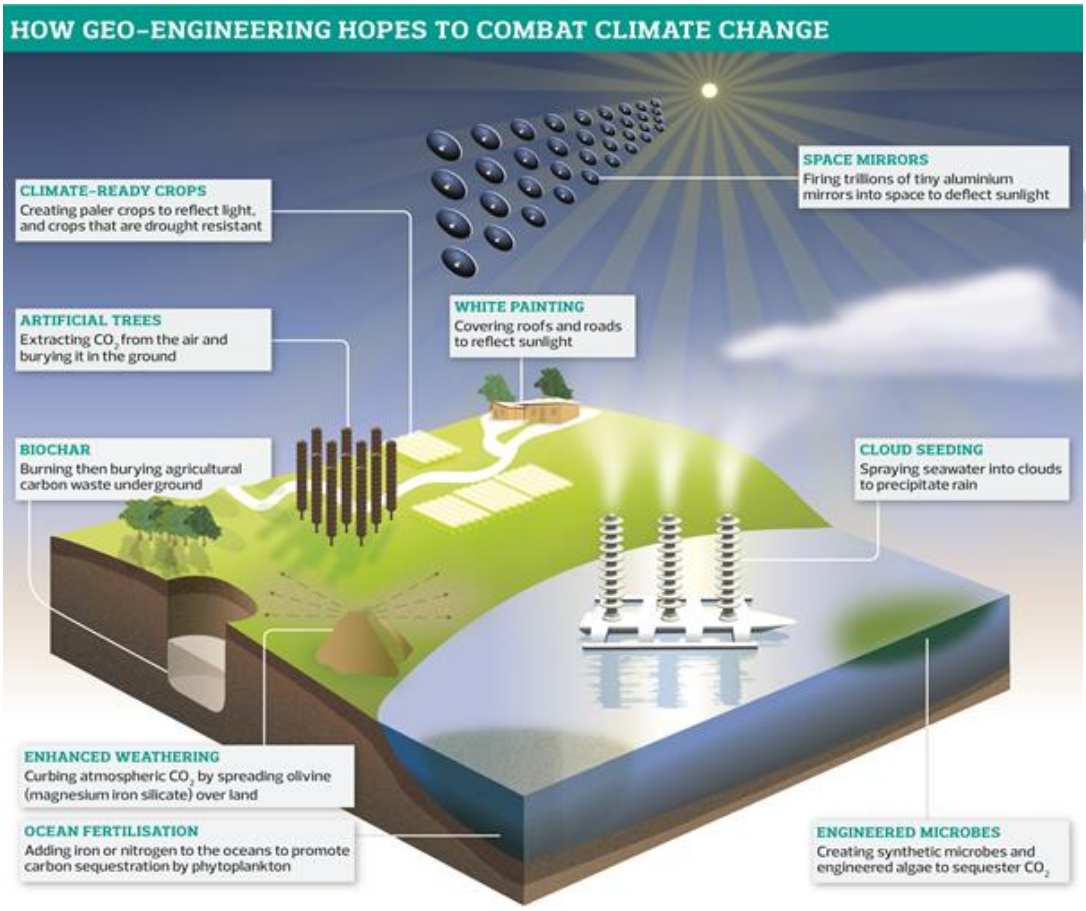
It can be done in the following ways:

- Afforestation
- Wetland Restoration
- Sustainable Agriculture

- Growing Seaweed that can be used to produce bio-methane.
- Bio-char produced by pyrolysis of bio waste. It can be used as landfill and increase soil fertility.
- Subterranean injection which involves injecting CO2 into depleted **oil and gas reservoirs** and other geological features, or into the deep **ocean**.
- Iron Fertilization of Oceans encouraging the growth of planktons and thus capturing CO2.

Geo-Engineering

It is large-scale **intervention in the Earth's climatic system** with the aim of limiting **climate change**. Theoretically, there are two major types of interventions – **Carbon Sequestration** and **solar radiation management**. Solar Radiation Management techniques include firing sulphur dioxide into atmosphere, putting huge mirrors in the space, creating pale coloured rooftop and other structures which have high albedo.



5.3. STRATOSPHERIC OZONE DEPLETION

A higher than normal concentration of Ozone molecules, called the Ozone layer, is found in Stratosphere. It acts as a shield absorbing ultraviolet radiation from the sun. UV rays are highly injurious to living organisms since DNA and proteins of living organisms preferentially absorb UV rays, and its high energy breaks the chemical bonds within these molecules.

The thickness of the ozone in a column of air from the ground to the top of the atmosphere is measured in terms of **Dobson units** (DU). 1 DU is equivalent to a layer of pure ozone molecules 0.01mm thick.

Ozone gas is continuously formed and destroyed by the action of UV rays on molecular oxygen, resulting in a dynamic equilibrium. Briefly, the process is:

1. Oxygen molecules photodissociate after intaking an ultraviolet photon whose wavelength is shorter than 240 nm. This converts a single O_2 into two atomic oxygen radicals.
2. The atomic oxygen radicals then combine with separate O_2 molecules to create two O_3 molecules.
3. These ozone molecules absorb UV light between 310 and 200 nm, following which ozone splits into a molecule of O_2 and an oxygen atom.
4. The oxygen atom then joins up with an oxygen molecule to regenerate ozone.

5. This is a continuing process that terminates when an oxygen atom "recombines" with an ozone molecule to make two O_2 molecules : $2\ O_3 \rightarrow 3\ O_2$

However, due to addition of **chlorofluorocarbons** (CFCs) in the atmosphere because of Human activity, this equilibrium has been disturbed.

CFCs **were** widely used as **refrigerants**. CFCs discharged in the lower part of atmosphere move upward and reach stratosphere. In stratosphere, their life-cycle is depicted below:

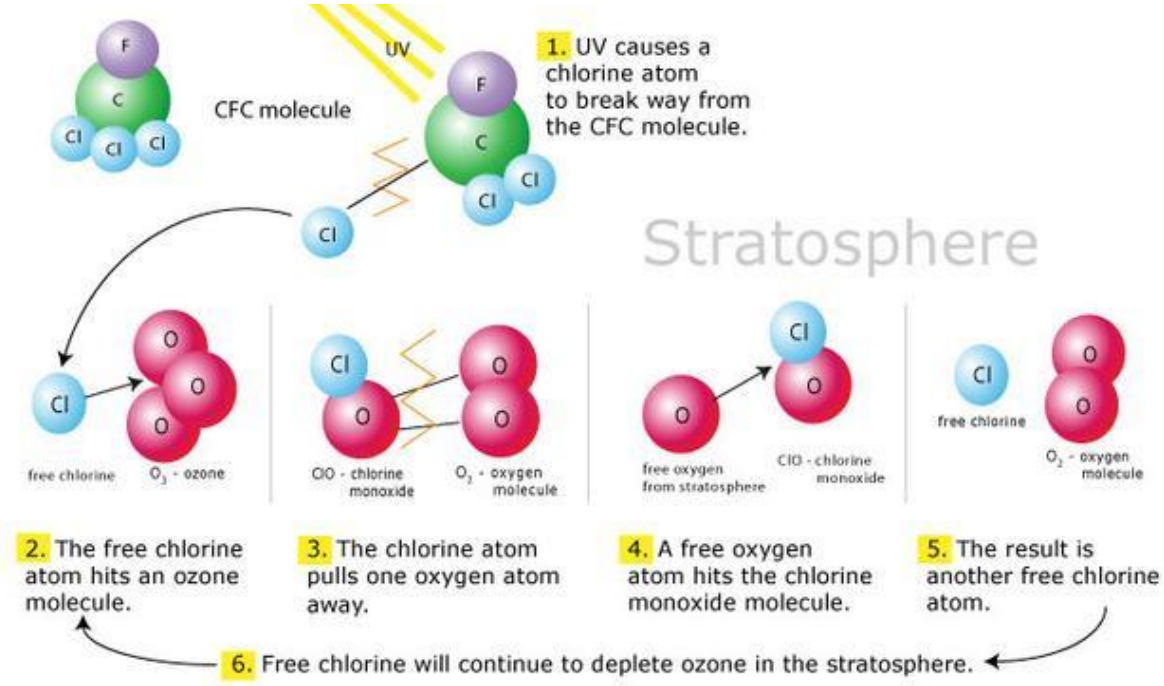


Figure: Catalytic destruction of ozone by atomic halogens

The main source of these halogen atoms in the stratosphere is photo-dissociation of man-made halocarbon refrigerants, solvents, propellants, and foam-blowing agents (CFCs, HCFCs, freons, halons) – popularly called as **ODS (Ozone Depleting Substance)**. These compounds are transported into the stratosphere by winds after being emitted at the surface. UV rays act on them releasing Chlorine atoms. Cl degrades ozone releasing molecular oxygen, with these atoms acting merely as catalysts. Thus Cl atoms are not consumed in the reaction. Hence, whatever CFCs are added to the stratosphere, they have permanent and continuing effects on Ozone levels.

Although ozone depletion is occurring widely in the stratosphere, the depletion is particularly marked over the Antarctic region. This has resulted in formation of a large area of thinned ozone layer, commonly called as the **ozone hole**. It is only under certain meteorological conditions that **ozone holes** form. The conditions required to form the ozone hole are:

- cold temperatures during the polar winter
- ice cloud formation
- special meteorological conditions to form the polar vortex
- followed by the polar sun rise in the spring

The ozone hole occurs during the Antarctic spring, from September to early December, as strong westerly winds start to circulate around the continent and create an atmospheric container. Within this polar vortex, over 50% of the lower stratospheric ozone is destroyed during the Antarctic spring.

Reactions that take place on polar stratospheric clouds (PSCs) dramatically enhance ozone depletion. PSCs form more readily in the extreme cold of the Arctic and Antarctic stratosphere. Sunlight-less polar winters contributes to a decrease in temperature and the polar vortex traps and chills air. These low temperatures form cloud particles. These clouds provide surfaces for chemical reactions whose products will, in the spring lead to ozone destruction.

Ordinarily, most of the chlorine in the stratosphere resides in "reservoir" compounds, primarily chlorine nitrate ($ClONO_2$) as well as stable end products such as HCl. The formation of end products essentially removes Cl from the ozone depletion process. During the Antarctic winter and spring, however, reactions on the surface of the polar stratospheric cloud particles convert these "reservoir" compounds into reactive free radicals (Cl and ClO). The clouds remove NO_2 from the stratosphere by converting it to nitric acid in the PSC particles. These are then lost by sedimentation. This prevents newly formed ClO from being converted back into $ClONO_2$.

The role of sunlight in ozone depletion is the reason why the Antarctic ozone depletion is greatest during spring. During winter, even though PSCs are at their most abundant, there is no light over the pole to drive chemical reactions. During the spring, however, the sun comes out, providing energy to drive photochemical reactions and melt the polar stratospheric clouds, releasing considerable ClO, which drives the whole mechanism. Warming temperatures near the end of spring break-up the vortex around mid-December. As warm, ozone and NO_2-rich air flows in from lower latitudes, the PSCs are destroyed, the enhanced ozone depletion process shuts down, and the ozone hole closes.

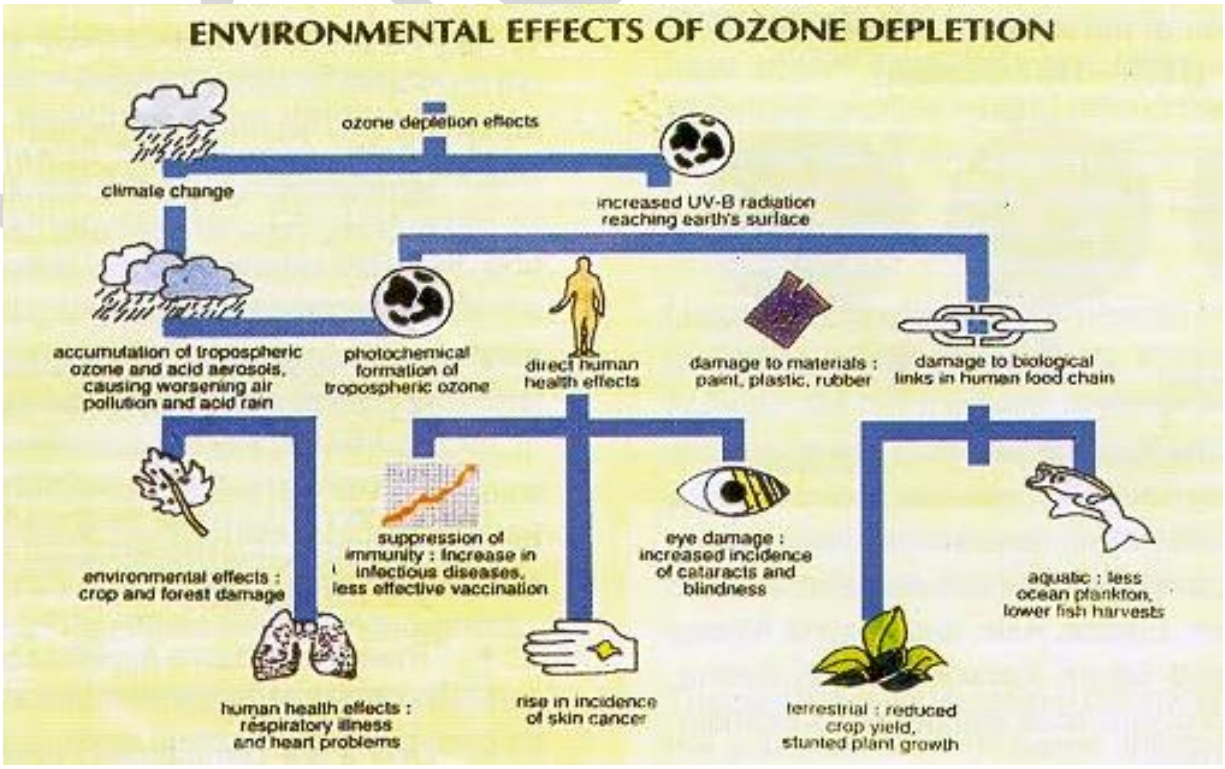
Role of Volcanoes and Ocean in Ozone Depletion

The main causes or events that pump excess Chlorine and ODS in the stratosphere are those that are human caused. Volcanoes and oceans contribute to some extent, but these are natural causes and they are taken care of by the natural production of Ozone in the stratosphere.

The vast majority of volcanic eruptions are too weak to reach the stratosphere, around 10 km above the surface. Thus, any HCl emitted in the eruption begins in the troposphere. Sea salt from the oceans is also released very low in the atmosphere. These compounds would have to remain airborne for 2-5 years to be carried to the stratosphere. However, both sea salt and HCl are extremely soluble in water, as opposed to CFCs which do not dissolve in water.

Researchers have also examined the potential impacts of other chlorine sources, such as swimming pools, industrial plants, sea salt, and volcanoes. However, chlorine compounds from these sources readily combine with water and rain out of the troposphere very quickly before they have a chance to reach the stratosphere. In contrast, CFCs are very stable and do not dissolve in rain. There are no natural processes that remove the CFCs from the lower atmosphere. Over time, winds drive the CFCs into the stratosphere.

5.3.2. CONSEQUENCES OF OZONE DEPLETION



Humans

Research confirms that high levels of UV rays cause non-melanoma skin cancer. Additionally, it plays a major role in malignant melanoma development. UV is also linked to cataract.

Tropospheric Ozone

Increased surface UV leads to increased tropospheric ozone. Ground-level ozone is generally recognized to be a health risk, as ozone is toxic due to its strong oxidant properties. The risks are particularly high for young children, the elderly, and those with asthma or other respiratory difficulties. Ozone at ground level is produced mainly by the action of UV radiation on combustion gases from vehicle exhausts.

Plants

Plant growths as well as its physiological and developmental process are all affected negatively. These include the way plants form, timing of development and growth, distribution of plant nutrients and metabolism, etc. these changes can have important implications for plant competitive balance, animals feeding on these plants, plant diseases and biogeochemical cycles.

P.S. - Plants do not use UV rays for photosynthesis. They may well have negative overall impact on photosynthesis.

Marine Ecosystems

Phytoplankton forms the foundation of aquatic food webs. These usually grow closer to the surface of water, where there is enough sunlight. A change in UV levels is known to affect the development and growth of phytoplankton and naturally, the fish that feed on them. UV radiation is also known to have affected the development stages of fish, shrimp, crab, amphibians and other animals. When this happens, animals in the upper food chain that feed on these tiny fishes are all affected. Whales' skin is also damaged due to exposure to high intensity of UV rays.

Biogeochemical Cycle

The power of higher UV level affects the natural balance of the gases including the greenhouse gases in the biosphere. Changes in UV level can cause biosphere atmospheric feedback resulting from the atmospheric build-up of these gases.

Crops

An increase of UV radiation would be expected to affect crops. A number of economically important species of plants, such as rice, depend on cyanobacteria residing on their roots for the retention of nitrogen. Cyanobacteria are sensitive to UV radiation and would be affected by its increase.

EFFECTS OF ENHANCED UV-B RADIATIONS ON CROPS

Possible changes in plant characteristics	Consequences	Selected sensitive crops
■ Reduced **photosynthesis** ■ Reduced **water-use efficiency** ■ Enhanced **drought stress sensitivity** ■ Reduced **leaf area** ■ Reduced **leaf conductance** ■ Modified **flowering** (either inhibited or stimulated) ■ Reduced **dry matter production**	Enhanced plant fragility Growth limitation Yield reduction	Rice Oats Sorghum Soybeans Beans

5.3.3. REMEDIAL MEASURES

- A very easy way to control ozone depletion would be to limit or reduce the amount of driving as vehicular emissions eventually result in smog which is a culprit in the deterioration of the ozone layer. (Smog is discussed in Air pollution section further).
- Usage of eco-friendly and natural cleaning products for household chores- many of these cleaning agents contain toxic chemicals that interfere with the ozone layer.
- Avoiding use of pesticides and using bio-control agents or exploring pest resistant GM crops.
- A study shows that the harm caused by rocket launches would outpace the harm caused due to CFCs. At present, the global rocket launches do not contribute hugely to ozone layer depletion, but over the course of time, it will become a major contributor to ozone depletion. All types of rocket engines result in combustion by products that are ozone-destroying compounds that are expelled directly in the middle and upper stratosphere.
- Putting N_2O under the Montreal Protocol as it is currently significant contributor to Ozone depletion while the contribution of others has decreased.

NASA Reports have claimed that Ozone layer over Antarctica is thickening again and would half close in the next five years.

5.4. DEFORESTATION

Forest clearance or **Deforestation** is the removal of a forest or stand of trees where the land is thereafter converted to a non-forest use. Examples of deforestation include conversion of forestland to farms, ranches, or urban use.

Deforestation occurs for many reasons: trees are cut down to be used or sold as fuel (sometimes in the form of charcoal) or timber, while cleared land is used as pasture for livestock, agriculture, plantations of commodities, industrialisation and settlements. Deforestation has also been used in war to deprive the enemy of cover for its forces and also vital resources. Disregard of ascribed value, lax forest management and deficient environmental laws are some of the factors that allow deforestation to occur on a large scale.

5.4.1. CONSEQUENCES OF DEFORESTATION

Climate Change: Forests are some of the largest reserves of carbon. Amazon rainforests are called lungs of the earth because of their ability absorb carbon dioxide and release fresh oxygen.

Pollution of Air, Water and Soil: Toxic gases and chemicals released into the environment are absorbed by the forests. Deforestation reduces this capacity and increases the impact of the pollution.

Water Cycle: Forests intercept moisture and cause rainfall. They play an important part in water cycle through transpiration and facilitation of cloud formation.

Soil: Deforestation generally increases rates of soil loss, by increasing the amount of runoff and reducing the protection of the soil from tree litter. Tree roots bind soil together, and if the soil is sufficiently shallow they act to keep the soil in place by also binding with underlying bedrock. Tree removal on steep slopes with shallow soil thus increases the risk of landslides, which can threaten people living nearby. Deforestation reduces soil cohesion, so that erosion, flooding and landslides ensue. It eventually leads to soil degradation as well.

Biodiversity: Deforestation on a human scale results in decline in **biodiversity**, and on a natural global scale is known to cause the extinction of many species. The removal or destruction of areas of forest cover has resulted in a degraded environment with reduced **biodiversity**. Forests support biodiversity, providing habitat for **wildlife**; moreover, forests foster **medicinal conservation**. With forest biotopes being irreplaceable source of new drugs (such as **taxol**), deforestation can destroy **genetic** variations (such as crop resistance) irretrievably.

5.5. LAND DEGRADATION AND DESERTIFICATION

Land degradation is caused by multiple forces, including extreme weather conditions particularly drought, and human activities that pollute or degrade the quality of soils and land utility. It negatively affects food production, livelihoods, and the production and provision of other ecosystem goods and services.

Land degradation has accelerated during the 20th and 21st century due to increasing and combined pressures of agricultural and livestock production (over-cultivation, overgrazing, forest conversion), urbanization, deforestation, and extreme weather events such as droughts and coastal surges which salinate land. Desertification, is a form of land degradation, by which fertile land becomes desert.

5.5.1. CONSEQUENCES OF LAND DEGRADATION

These social and environmental processes are stressing the world's arable lands and pastures essential for the provision of food, water and quality air. Land degradation and desertification can affect human health through complex pathways. As land is degraded and in some places deserts expand, food production is reduced, water sources dry up and populations are pressured to move to more hospitable areas. The potential impacts of desertification on health include:

- Higher threats of malnutrition from reduced food and water supplies;
- More water- and food-borne diseases that result from poor hygiene and a lack of clean water;
- Respiratory diseases caused by atmospheric dust from wind erosion and other air pollutants;
- Spread of infectious diseases as populations migrate.

5.6. WETLANDS LOSS AND DAMAGE

Wetlands are defined as lands **transitional between terrestrial and aquatic eco-systems** where the water table is usually at or near the surface or the land is covered by shallow water. The land area is saturated with water, either permanently or seasonally, such that it takes on the characteristics of a distinct ecosystem.

Wetlands are the **most productive ecosystems** that provide many services and commodities to humanity. Regional wetlands are integral parts of larger landscapes; their functions and values to the people in these landscapes depend on both their extent and their location. Each wetland thus is ecologically unique. Some important uses of wetlands:

- **Aquaculture:** Wetlands are used to harvest fish/aquatic animals for human consumption and pharmaceuticals.
- **Flood control**
- **Groundwater replenishment:** The surface water which is the water visibly seen in wetland systems only represents a portion of the overall water cycle which also includes atmospheric water and groundwater. Wetland systems are directly linked to groundwater and a crucial regulator of both the quantity and quality of water found below the ground.
- **Shoreline stabilisation and storm protection:** Tidal and inter-tidal wetland systems protect and stabilize coastal zones. Coral reefs and mangroves provide a protective barrier to coastal shoreline.
- **Nutrient retention:** Wetland vegetation up-take and store nutrients found in the surrounding soil and water.
- **Sediment traps**
- **Water purification:** Many wetland systems possess biofilters, hydrophytes, and organisms that in addition to nutrient up-take abilities have the capacity to remove toxic substances that have come from pesticides, industrial discharges, and mining activities.
- **Reservoirs of biodiversity**
- **Wetland products:** Apart from aquaculture products, wetland systems naturally produce an array of vegetation and other ecological products that can harvested for personal and commercial use. Some important products: rice, sago palm, nipa palm, honey from mangroves, Fuel wood, Salt (produced by evaporating seawater), Animal fodder, Traditional medicines (e.g. from mangrove bark), Fibres for textiles, Dyes and tannins.
- **Cultural values**

- **Recreation and tourism**
- **Climate change mitigation and adaptation:** Wetlands perform two important functions in relation to climate change. They have mitigation effects through their ability to sink carbon, and adaptation effects through their ability to store and regulate water. However, coastal wetlands, such as tropical mangroves and temperate salt marshes are also emitters of nitrous oxide (N_2O). In Southeast Asia, peatswamp forests and soils are source of CO2. Rice fields are source of methane.

5.6.1. CAUSES OF WETLAND LOSS IN INDIA

Human Causes:

- Drainage for agriculture, forestry and mosquito control
- Dredging and stream channelization for navigation and food protection
- Filling for solid waste disposal, roads
- Conservation for aquaculture/mariculture
- Construction of dykes, dams and seawalls for flood control
- Discharge of pesticide, herbicide, nutrients from domestic sewage
- Mining of wetlands for peat, coal, gravel, phosphate and other minerals
- Ground water abstraction
- Sediment diversion by dams, deep channels
- Hydrological alterations by canals, roads and other structures
- Subsidence due to extraction of ground water oil, gas and other minerals

Natural Causes:

- Subsidence
- Sea level rise
- Drought
- Hurricane and other storms
- Erosions
- Biotic effects

(Kindly refer to Wetlands Document where the topic has been discussed elaborately)

5.7. URBANIZATION

Urbanization is the gradual increase in proportion of people living in urban areas and ways in which each society adapts to the change. It is mostly driven by rural-urban migration, which is more often than not based on environmental and economic distress. Rapid, unplanned and unsustainable patterns of urban development are making developing cities focal points for many emerging environment and health hazards. As urban populations grow, the quality of global and local ecosystems, and the urban environment, will play an increasingly important role in public health with respect to issues ranging from solid waste disposal, provision of safe water and sanitation, and injury prevention, to the interface between urban poverty, environment and health.

Figure depicting consequences of unplanned urbanization

5.8. DAMAGE TO CORAL REEFS

Coral reefs are some of the most diverse ecosystems in the world, housing tens of thousands of marine species. Thousands of identical polyps live together and form a coral colony. Each polyp excretes a calcium carbonate exoskeleton beneath it and, over long periods of time, the skeletons of many coral colonies add up to build the structure of a coral reef. Reefs only occur in shallow areas that are reachable by sunlight because of the relationship between coral and algae. Various types of microscopic algae live inside of the coral, providing them with food and helping them to grow faster. In many ways, reef-building corals are animals that act like plants- they stay in one place and get some of their energy from the sun. Coral reefs cover an area of over 280,000 km^2 and are described as the "**rainforests of the seas**" because of the biodiversity they support.

Coral reefs benefit the environment and people in numerous ways. For example, they

- Through the photosynthesis carried out by their algae, coral serve as a vital input of food into the tropical/sub-tropical marine food-chain, and assist in recycling the nutrients too.
- The reefs provide home and shelter to over 25% of fish and up to two million marine species.
- They are also a nursery for the juvenile forms of many marine creatures.
- Protect shores from the impact of waves and from storms;
- Provide benefits to humans in the form of food and medicine; economy through tourism.
- The World Meteorological Organization says that tropical coral reefs yield more than US$ 30 billion annually in global goods and services, such as coastline protection, tourism and food.

Threat to coral reefs

- **According to a 2004 report,** 20% of the world's coral reefs have been effectively destroyed and show no immediate prospects of recovery;
- The report predicts that 24% of the world's reefs are under imminent risk of collapse through human pressures; and a further 26% are under a longer term threat of collapse.

The 2004 edition of Status of Coral Reefs around the World lists the following top 10 emerging threats in these three categories:

Global Change Threats	• Coral bleaching—caused by elevated sea surface temperatures due to global climate change; • Rising levels of CO2 causing ocean acidification • Diseases, Plagues and Invasives—linked to human disturbances in the environment.
Direct Human Pressures	• Over-fishing (and global market pressures)—including the use of damaging practices (bomb and cyanide fishing); • Sediments—from poor land use, deforestation, and dredging; • Nutrients and Chemical pollution • Development of coastal areas—for urban, industrial, transport and tourism developments, including reclamation and mining of coral reef rock and sand beyond sustainable limits.
The Human Dimension-Governance, Awareness and Political Will	• Rising poverty, increasing populations, alienation from the land • Poor capacity for management and lack of resources • Lack of Political Will, and Oceans G

In 1995, France started testing its Nuclear weapons in the Pacific despite huge protests. It is now emerging that the coral in the French Polynesia regions where many Nuclear tests have been carried out have been harmed, as the French atomic energy commission has admitted.

5.9. POLLUTION

Pollution is **any undesirable change in physical, chemical or biological characteristics of air, land, water or soil**. Agents that bring about such an undesirable change are called as **pollutants**.

Pollution is often classed as **point source** or **nonpoint source** pollution. A point source is a single, identifiable source of pollution, such as a pipe or a drain. Industrial wastes are commonly discharged to rivers and the sea in this way. Non-point sources of pollution are often termed 'diffuse' pollution and refer to those inputs and impacts which occur over a wide area and are not easily attributed to a single source. For example as water from rainfall and snowmelt flows over and through the landscape, it picks up and carries contaminants from many different sources. This is called Non-Point Source pollution.

5.9.1. AIR POLLUTION

Air pollution is the introduction of particulates, biological molecules, or other harmful materials into Earth's atmosphere, causing damage, diseases and death to living organisms. Industry and transport are the largest sources of air pollutants and emission of these pollutants results in high levels of particles and soot in the air and can cause smog to form. Air pollutants can be either gases or **aerosols** (particles or liquid droplets suspended in the air). They change the natural composition of the atmosphere and can cause damage to natural water bodies and the land.

Air pollution has both natural and human sources:

Natural air pollution

- Dust from natural sources, usually large areas of land with little or no vegetation
- Methane, emitted by various sources.
- Radon gas from radioactive decay within the Earth's crust.
- Smoke and carbon monoxide from wildfires
- Vegetation, in some regions, emits environmentally significant amounts of Volatile organic compounds (VOCs) on warmer days. These VOCs react with primary anthropogenic pollutants—specifically, NO_x, SO_2, and anthropogenic organic carbon compounds — to produce a seasonal haze of secondary pollutants. Black gum, poplar, oak and willow are some examples of vegetation that can produce abundant VOCs. The VOC production from these species results in ozone levels up to eight times higher than the low-impact tree species.
- Volcanic activity, which produces sulfur, chlorine, and ash particulates

Anthropogenic sources

- **Stationary sources** include smoke stacks of power plants, factories and waste incinerators, as well as furnaces and other types of fuel-burning heating devices. In developing and poor countries, traditional biomass burning is the major source of air pollutants; traditional biomass includes wood, crop waste and dung.
- **Mobile sources** include motor vehicles, marine vessels, and aircraft.
- **Fumes** from paint, hair spray, varnish, aerosol sprays and other solvents
- **Waste deposition** in landfills, which generate methane. Methane is also an asphyxiant and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement.
- **Military resources**, such as nuclear weapons, toxic gases, germ warfare and rocketry
- **Particulate matter** from mining activities.

Types of Pollutants

1. **Primary Pollutants:** These are emitted directly into the air from sources at the Earth's surface. Examples are greenhouse gasses.
2. **Secondary Pollutants:** The regional gases can also react chemically in the atmosphere to form other compounds which are known as secondary pollutants. One of the main results of secondary pollution is **photochemical smog**.

Apart from gasses, the second type of pollutant is **Particulate matter** which consists of a wide range of liquid and solid particles known scientifically as **aerosols**. The smallest of these particles are hazardous to human health. As with the gases, particles can be directly emitted into the air or can form from gases. For example such particles from wood-burning can cause a brown haze over the region and larger particles may interfere with plant growth because they deposit on the leaves.

National Carbonaceous Aerosols Programme (NCAP)

India launched the **Black Carbon Research Initiative** as part of the National Carbonaceous Aerosols Programme (NCAP). This is a joint initiative of several government ministries and leading research institutions.

Black carbon (BC) is the result of incomplete combustion of fossil fuels, biofuel, and biomass. It consists of elemental carbon in several forms. Black carbon warms the atmosphere due to its absorption and by reducing albedo when deposited on snow and ice. Life time of black carbon in the atmosphere is only a few days to weeks, compared to CO2 which has an atmospheric lifetime of more than 100 years.

Aerosols are suspended particulates in the atmosphere and have implications for climate and health through different mechanisms Direct and indirect climate forcing by aerosols depend on the physical and chemical properties of the composite aerosol, which consist mainly of sulfates, carbonaceous material, sea salt and mineral particles. Among the various aerosol types, black carbon aerosol assumes most importance due to its high absorption characteristics, which in turn depends on its production mechanism. Until the late nineties, sulfate aerosols had received most attention because of its scattering effects and its ability to act as **Cloud Condensation Nucleus (CCN)**. Studies carried out during the late nineties, however, have identified carbonaceous aerosols as one of the most important contributors to aerosol forcing. Carbonaceous aerosols are the result of burning coal, diesel fuels, bio fuels and biomass burning.

Indoor Air Pollution

The air pollution types mentioned so far are also known as **outdoor air pollution**. **Indoor air pollution** is also a very important problem. The air within homes and other buildings can sometimes be more polluted than the outdoor air even in the largest and most industrialised cities. Indoor air quality is an important concern for the health and comfort of the occupants. Some of the sources of indoor air pollution are:

1. **Radon:** Radon is an invisible, radioactive atomic gas that results from the radioactive decay of **radium**, which may be found in rock formations beneath buildings or in certain building materials themselves. Radon is the second most frequent cause of lung cancer, after cigarette smoking.
2. **Second-hand smoke:** It is tobacco smoke which affects other people other than the 'active' smoker. It includes both a gaseous and a particulate phase, with particular hazards arising from levels of carbon monoxide and very small particulates.
3. **Biological chemicals:** They can arise from a host of means, like moisture induced growth of mould colonies and natural substances released into the air such as animal dander and plant pollen. They are allergens and aggravate **asthama**.
4. **Volatile organic compounds (VOCs)**: They are emitted as gases from certain solids or liquids like paints and lacquers, pesticides, building materials and furnishings, office equipment, correction fluids, glues and adhesives, permanent markers, and photographic solutions.
5. **Carbon monoxide:** Sources of carbon monoxide are tobacco smoke, space heaters using fossil fuels, defective central heating furnaces, and automobile exhaust.6. **Bacteria:** Many **bacteria** of health significance found in indoor air and on indoor surfaces.
6. **Ozone:** Ozone is produced by **ultraviolet light** from the Sun hitting the Earth's atmosphere, **lightning**, certain **high-voltage** electric devices and as a by-product of other types of pollution.

Sources of indoor air pollutants are of many types and this is a serious problem particularly in poor countries where the standard of living is low.

Air Freshener

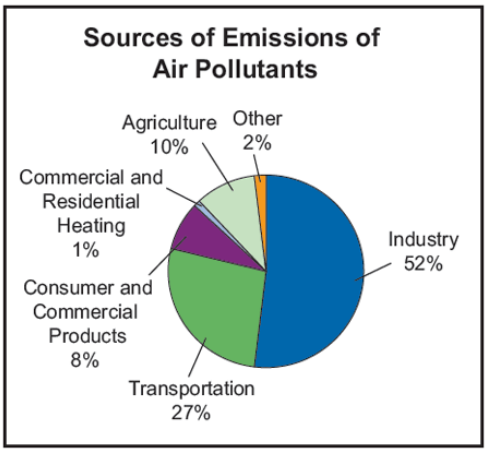
Many air fresheners employ **carcinogens**, **volatile organic compounds** and known **toxins** such as **phthalate esters** in their formulas. Most of the products that have been studied contain chemicals that can aggravate asthma and affect reproductive development.

Emissions and their Quantification

Burning fuels such as coal, oil, gas and petrol to produce energy and to power vehicles causes the emission of many different chemical species into the atmosphere.

Large amounts of both gases and particles are emitted into the air when coal is burnt in power stations. The gases emitted include sulphur dioxide (SO2), nitrogen oxides (NOx), carbon monoxide (CO) and carbon dioxide(CO2) and the dust contains heavy metals such as lead (Pb), zinc (Zn) and cadmium (Cd). The exhaust gasses from petrol engines contain Carbon Monoxide and Nitrogen Oxides, hydrocarbons, some Sulphur Dioxide and solid particles. **Diesel Engines emit less toxic gasses but may emit more particles.**

Metallurgy is the main industrial source of air pollution delivering primarily sulphur dioxide (SO2) and highly toxic heavy metal containing dust. **Steel works** emit large amounts of carbon monoxide (CO), and **aluminum works** produce lots of fluorine which is very harmful to living organisms.



Particles not only come from the combustion of fossil fuels but also from the **road surface and from the car tyres and the brakes**. Most cars are now equipped with catalytic converter which significantly reduce the amount of pollutants being emitted. However the numbers of cars globally is still rising and vehicles are still an important source of air pollution. **The catalysts in catalytic converters are made up of heavy metals including platinum, palladium and rhodium.** Increasing numbers of cars and therefore catalytic converters mean that levels of these metals are increasing in the atmosphere.

Emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e. g., kilograms of particulate emitted per megagram of coal burned). Such factors facilitate estimation of emissions from various sources of air pollution.

Negative Effects of Air Pollution

Air pollution has an impact on both local and global scales. Harmful substances which are emitted into the atmosphere in one country are transported by the wind and cross over national borders. Global negative effects of air pollution include the enhanced greenhouse effect and the ozone hole. Smog and acid rain are the best known local effects and smog, in particular, affects people living in urban areas. Air pollution is a threat to our health and can also cause economic losses.

Humans

It is detrimental to human health causing major respiratory disorders. Hay fever, asthma and bronchitis are caused due to air pollution. Sulphur dioxide is responsible for cough, spasm of larynx and reddening of the eye due to irritation of membranes in the eye. Haemorrhage and pulmonary disorders are resulted even with very low concentrations of ozone. Beryllium causes berylliosis. Dusts, grits and smokes cause tuberculosis and silicosis whereas heavy metals are carcinogenic in nature and develop dermatitis and ulcers of skin. Nickel may cause lung cancer.

Animals

The forage crops are sometimes contained with metallic pollutants, such as, lead, arsenic and molybdenum in mining and thermal power plants area due to air pollution. The domestic animals feeding on contaminated fodder suffer from different diseases. Air contaminated with ozone causes pulmonary changes, oedema and haemorrhage in dogs, cats, and rabbits. Animals feeding on fluoride compound containing fodder may suffer from fluorosis. Cattle and sheep are most frequently affected animals. Hypoplasia of dental enamel and bone lessening are the other effects caused due to excessive fluoride in the body.

Plants

Plants are affected by various air pollutants. Excessive sulphur dioxides make the cells inactive and finally are killed. At lower concentrations, brownish red colour of leaf, choruses and necrosis take place. Tomato is affected by ammonia and radish, cucumber and soybean are affected due to hydrogen sulphite. Ethylene causes epinasty and early maturation of plants. In India in 2014, it was reported that air pollution by black carbon and ground level ozone had cut crop yields in the most affected areas by almost half in 2010 when compared to 1980 levels.

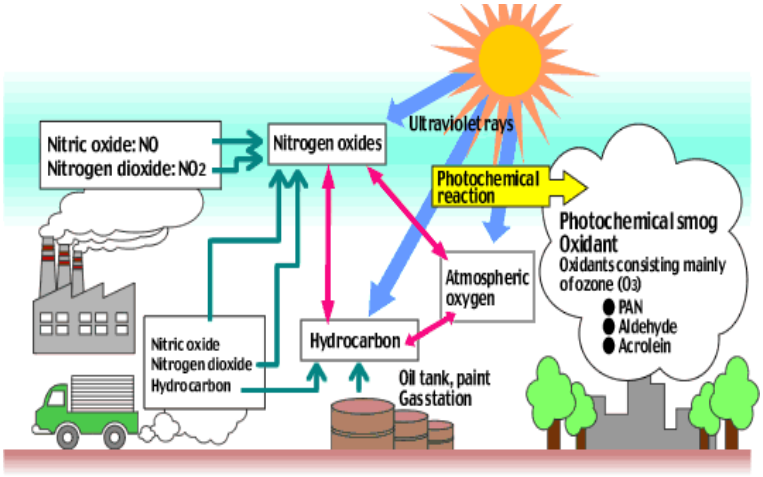
Materials and atmosphere

Increase in carbon dioxide concentration increases the temperature of the earth. Depletion of ozone layer due to fluorocarbon of aerosol causes the exposure of U. V. radiation which is lethal. Different metals, such as iron, aluminum and copper are corroded when exposed to contaminated air. Building and other materials are disfigured by deposition of soot.

Smog

The word "smog" is the combination of the words smoke and fog. It was invented around 1911 by the physician Harold Des Voeux. There are two kinds of smog:

1. **London type smog**: Burning coal leads to emissions of Carbon Dioxide, Sulphur Dioxide and dust. When these pollutants mix with fog, droplets of highly corrosive Sulphuric Acid are produced in the air. It occurs at very cold temperatures.
2. **Los Angeles type or Photochemical Smog**: This type of smog forms on sunny days and is the result of emissions from traffic. Nitrogenous oxides from car exhausts and hydrocarbons react in the presence of sunlight to produce a noxious mixture of aerosols and gasses.



Secondary pollutants: Derived from Primary Air Pollutants. In bright sunlight, nitrogen, nitrogen oxides, oxygen and hydrocarbons undergo photochemical reaction. As a result, powerful oxidants – Ozone, Aldehydes, Sulphuric acid, Peroxy acetyl nitrate (PAN), Peroxides, etc. are produced. They form photochemical Smog.

Photochemical smog contains tropospheric ozone, formaldehyde, ketones and PAN (peroxyacetyl nitrates). Normal tropospheric ozone levels are less than 0.04 ppm but ozone levels can be as high as 12 ppm in these smogs. The substances in these smogs are irritating to eyes and can damage respiratory system. They also affect vegetation. This type of smog is rather common now in large cities.

Acid Rain

Clean rain is slightly acidic naturally but **when the pH of rain falls below 5.6**, we call it acid rain. Emissions of the two air pollutants, nitrogen oxides (NOx) and sulphur dioxide (SO2) are the main reasons for acid rain formation. Nitrogen oxides (NOx = NO + NO2) and sulphur dioxide (SO2) are emitted during fossil fuel combustion and then undergo reactions with water in the air to form the nitric acid (HNO3) and the sulphuric acid (H2SO4) found in acid rain.

Acid rain affects all elements of the environment, surface- and ground-water, soils and vegetation. It negatively affects food chains, reduces biodiversity and damages our world as discussed below:

- When soil becomes acidified, essential nutrients such as calcium (Ca) and magnesium (Mg) are leached out before the trees and plants can use them to grow. This reduces the soil's fertility. In addition, acidification may release[1] aluminium from the soil. At high concentrations, aluminium is toxic and damages plant roots. This reduces the plants ability to take up nutrients such as phosphorus, eventually leading to death.
- It leads to acidification of water bodies. Some 14,000 Swedish lakes, located in acidic crystalline rocks, have been affected by acidification with widespread damage to plant and animal life as a consequence.
- Acid precipitation does not usually kill trees directly. Acid deposition destroys the surfaces of the leaves of trees and plants. This damage causes uncontrolled water loss and slows photosynthesis. It reduces the rate at which leaf litter decomposes, causes the death of useful microorganisms present in tree roots and reduces the rate at which soil organisms (including bacteria) respire.
- Soil acidification releases metals that can harm microorganisms in the soil as well as birds and mammals higher up in the food chain. The most sensitive groups include fish, lichens, mosses, certain fungi and small aquatic organisms. Some organisms may be completely eliminated, reducing biodiversity.
- Acid rain also disturbs the natural cycles of sulphur and nitrogen.

Toxic hotspots are locations where emissions from specific sources such as water or air pollution may expose local populations to elevated health risks, such as cancer. Urban, highly populated areas around pollutant emitters such as old factories and waste storage sites are often toxic hotspots. Some toxic hotspots in India are Bhopal, Pantacheru, AP and Eloor in Cochin.

[1] At higher Ph metal ions are dissolved into the water and become toxic to plants.

Remedial Measures

Some of the effective methods to Control Air Pollution are as follows:

1. Source Correction Methods:

Industries are major contributors towards air pollution. Formation of pollutants can be prevented and their emission can be minimized at the source itself. By carefully investigating the early stages of design and development in industrial processes e.g., those methods which have minimum air pollution potential can be selected to accomplish air-pollution control at source itself. Some of these source correction methods are:

Fly ASH

When pulverized coal is burnt in the boiler of a thermal power station, a part of ash falls down at the bottom of the boiler and is known as bottom ash. Whereas, the major portion of the ash comes out along with the flue gases and is collected through electro static precipitator or filter bags or other means before allowing the exhaust gases to escape through chimney. This is called Fly Ash.

Fly Ash is categorised as hazardous waste and therefore, pollution control standards require that it be captured prior to release. However, it has found number of uses. The most common use of fly ash is as a replacement for Portland cement used in producing concrete. Concrete made with fly ash is stronger and more durable than traditional concrete. Fly ash concrete is easier to pour, has lower permeability, and resists alkali-silica reaction, which results in a longer service life

(i) Substitution of raw materials:

(a) Low sulphur fuel which has less pollution potential can be used as an alternative to high Sulphur fuels, and,

(b) Comparatively more refined liquid petroleum gas (LPG) or liquefied natural gas (LNG) can be used instead of traditional high contaminant fuels such as coal.

(ii) Process Modification:

(a) If coal is washed before pulverization, then fly-ash emissions are considerably reduced.

(b) If air intake of boiler furnace is adjusted, then excess Fly-ash emissions at power plants can be reduced.

(iii) Modification of Existing Equipment:

(a) Smoke, carbon-monoxide and fumes can be reduced if open hearth furnaces are replaced with controlled basic oxygen furnaces or electric furnaces.

(b) In petroleum refineries, loss of hydrocarbon vapours from storage tanks due to evaporation, temperature changes or displacement during filling etc. can be reduced by designing the storage tanks with floating roof covers.

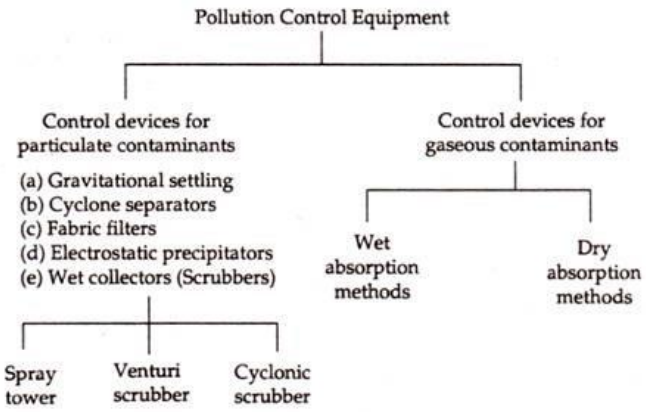
(c) Pressurising the storage tanks in the above case can also give similar results.

(iv) Maintenance of Equipment: An appreciable amount of pollution is caused due to poor maintenance of the equipment which includes the leakage around ducts, pipes, valves and pumps etc. Emission of pollutants due to negligence can be minimized by a routine checkup of the seals and gaskets.

2. Pollution Control Equipment:

Sometimes pollution control at source is not possible by preventing the emission of pollutants. Then it becomes necessary to install pollution control equipment to remove the gaseous pollutants from the main gas stream.

Pollution control equipment's are generally classified into two types:



Control Devices for Particulate Contaminants:

(1) Gravitational Settling Chamber: For removal of particles exceeding 50 µm in size from polluted gas streams, gravitational settling chambers are put to use. The gas stream polluted with particulates is allowed to enter from one end. The particulates having higher density obey Stoke's law and settle at the bottom of the chamber from where they are removed ultimately.

(2) Cyclone Separators (Reverse flow Cyclone): Instead of gravitational force, centrifugal force is utilized by cyclone separators, to separate the particulate matter from the polluted gas.

(3) Fabric Filters (Baghouse Filters): In a fabric filter system, a stream of the polluted gas is made to pass through a fabric that filters out the particulate pollutant and allows the clear gas to pass through.

(4) Electrostatic Precipitators*:* Electrically charged particulates present in the polluted gas are separated from the gas stream under the influence of the electrical field.

(5) Wet Collectors (Scrubbers): In wet collectors or scrubbers, the particulate contaminants are removed from the polluted gas stream by incorporating the particulates into liquid droplets.

3. Diffusion of Pollutants in Air:

Dilution of the contaminants in the atmosphere can be accomplished through the use of tall stacks which penetrate the upper atmospheric layers and disperse the contaminants so that the ground level pollution is greatly reduced. The height of the stacks is usually kept 2 to $2^1/_2$ times the height of nearby structures.

Dilution of pollutants in air depends on atmospheric temperature, speed and direction of the wind. The disadvantage of the method is that it is a short term contact measure which in reality brings about highly undesirable long range effects because they are less noticeable near their original source whereas at a considerable distance from the source these very contaminants eventually come down in some form or another.

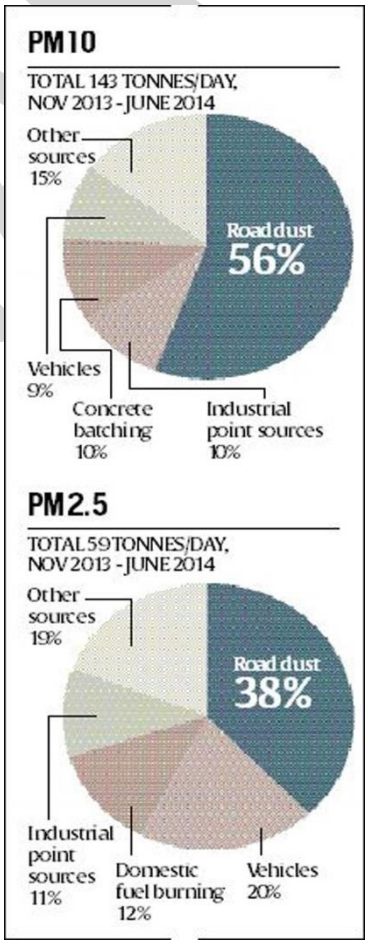


Fig A Sources of Air pollution in Delhi

4. Vegetation:

Plants contribute towards controlling air-pollution by utilizing carbon dioxide and releasing oxygen in the process of photosynthesis. This purifies the air (removal of gaseous pollutant—CO_2) for the respiration.

Gaseous pollutants like carbon monoxide are fixed by some plants, namely, Coleus Blumeri, Ficus variegata and Phascolus Vulgaris. Species of Pinus, Quercus, Pyrus, Juniperus and Vitis depollute the air by metabolising nitrogen oxides. Plenty of trees should be planted especially around those areas which are declared as high-risk areas of pollution.

5. Zoning:

This method of controlling air pollution can be adopted at the planning stages of the city. Zoning advocates setting aside of separate areas for industries so that they are far removed from the residential areas. The heavy industries should not be located too close to each other.

New industries, as far as possible, should be established away from larger cities (this will also keep a check on increasing concentration of urban population in a few larger cities only) and the locational decisions of large industries should be guided by regional planning. The industrial estate of Bangalore is divided into three zones namely light, medium and large industries. In Bangalore and Delhi very large industries are not permitted.

Air pollution in India

Air pollution in India is a serious issue with the major sources being fuelwood and biomass burning, fuel adulteration, vehicle emission and traffic congestion. The Air (Prevention and Control of Pollution) Act was passed in 1981 to regulate air pollution and there have been some measurable improvements. However, the 2013 Environmental Performance Index ranked India 155 out of 178 countries.

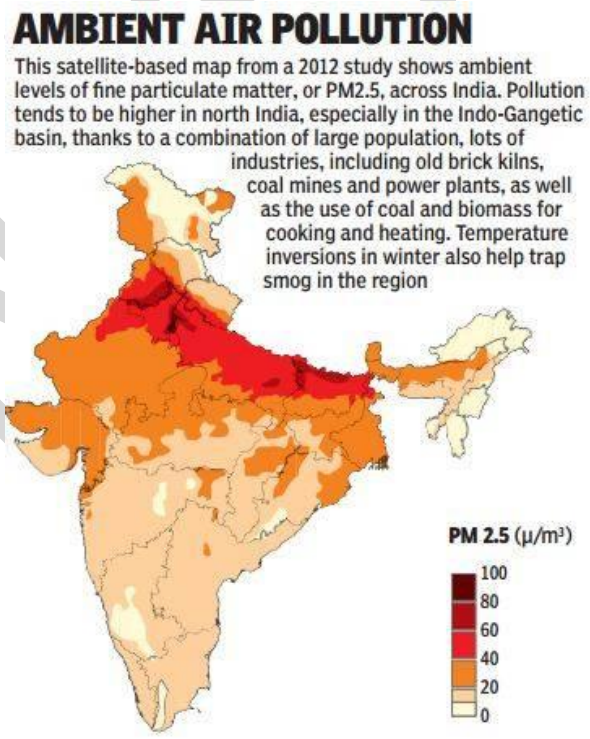
The ambient air quality is monitored by the Central Pollution Control Board in association with various State Pollution Control Boards, Pollution Control Committees for Union Territories and NEERI across the country, including in 35 metro cities in terms of Sulphur Dioxide (SO2), Nitrogen Dioxide (NO2) and PM10 (particulate

matter less than 10 micron) under National Air Monitoring Programme (NAMP. The basic guidelines to prevent air pollution arising due to transport sector, industry sector, energy sector, etc. in metro cities, are followed by different organs of the Administration and concerned organisations.

The steps being taken include, inter alia, strengthening of public transport, supply of cleaner fuel as per Auto Fuel Policy, use of beneficiated coal in thermal power plants, more stringent mass emission norms for new vehicles in select cities, 'Pollution Under Control' certificate system for in-use vehicles, strict implementation of emission & effluent norms in air and water polluting industries, etc. with a view to contain pollution in the cities. Concerned authorities implement city-specific Ambient Air Quality Improvement Programme for 17 identified cities. The Central Government has very recently established a National Ambient Noise Monitoring Network in seven cities, namely, Delhi, Mumbai, Kolkata, Lucknow, Bengaluru, Chennai and Hyderabad, to begin with, for systematic monitoring of ambient noise on 24 X 7 basis and for creation of baseline data.

Bharat Stage emission standards

The standards, based on European regulations were first introduced in 2000. Progressively stringent norms have been rolled out since then. All new vehicles manufactured after the implementation of the norms have to be compliant with the regulations. Since October 2010, Bharat stage III norms have been enforced across the country. In 13 major cities, Bharat stage IV emission norms for cars have been in place since April 2010. Government has announced that all two-wheelers, three-wheelers and four-wheelers will have to comply with Bharat Stage IV (BS IV) norms from April 1, 2017. It has announced plans to skip BS V norms and directly implement BS VI norms by April 2020. However, compliance with the norms leads to increase in the cost of the vehicles.



National Air Quality Index (AQI)

It has been launched for monitoring the **quality of air in major urban centres** across the country on a real-time basis and enhancing public awareness for taking mitigative action. The AQI has been at present launched for 10 cities -- Delhi, Agra, Kanpur, Lucknow, Varanasi, Faridabad, Ahmedabad, Chennai, Bangalore and Hyderabad. Government proposes to extend the measurement of air quality to 22 state capitals and 44 other cities with a population exceeding one million.

There are **six AQI categories**, namely: Good, Satisfactory, Moderately polluted, Poor, Very poor and Severe.

The index considers eight pollutants -- PM10, PM2.5, NO2, SO2, CO, O3, NH3 and Pb). The likely health implications of the six categories would also be provided with a colour code.

With this step, India has joined the global league of countries like the US, China, Mexico and France that have implemented smog alert systems.

5.9.2. WATER POLLUTION

Water pollution may be defined as the presence of undesirable substances (organic, inorganic, biological or radioactive) in water and such physical factors as heat, which make it unfit and harmful for use by the human beings, animals and marine life.

Marine water pollution has assumed greater significance because in the present age of technology and large scale industrialization, the coastal areas of oceans and seas are most vulnerable to pollution. These areas receive direct discharges from the rivers, which carry a large amount of dissolved and particulate matter. The oceans and seas are being used as endless dustbins for wastes.

Sources of Water Pollution

Major sources of water pollution are as below:

- **Domestic Sewage:** Human beings use water for drinking, cooking, bathing, washing clothes, gardening, recreation, etc. The discharged water has soluble and insoluble, organic and inorganic matter. It includes detergents, toxic heavy metals and even pathogens. In the municipal drains the domestic sewage is mixed up with garbage from urban and rural settlements. This highly polluted water is discharged into rivers, lakes and ponds. Thus the domestic waste and garbage are the main source of water pollution.
- **Industrial Waste:** The industrial wastes are most harmful of all water pollutants as they contain toxic metals (lead, mercury, zinc, copper, chromium and cadmium) and toxic non-metals (arsenic, acids, alkalis, cellulose fibers, coloring and bleaching materials, petrochemicals, etc.). These pollutants are continuously discharged in the water bodies either directly or from waste dumps.
- **Agricultural Waste:** Water pollution caused by agriculture is mainly an outcome of fertilizers and agricultural chemicals such as insecticides and herbicides that runoff into streams and lakes. They are rich in many nutrients and lead to phenomenon like eutrophication.
- **Off-shore Oil Drilling:** This pollution is mainly due to the loss of oil during off-shore exploration, oil drilling and extraction of mineral oil, leakage of oil and natural gas from under-water pipelines and oil spills from oil tankers. The waste oil also reaches the oceans and seas due to leakage during loading and unloading of oil tankers, run off from the roads at seaports and washing of oil tankers.
- **Thermal Pollution:** Most of the large-scale industrial units, thermal power plants, nuclear power plants, oil refineries, etc., are located along the banks of rivers. **These industries use large quantities of fresh water for cooling purposes**. The hot water is generally discharged in the rivers. **This increases the temperature of river water by about 10 Degree Celsius, and this leads to thermal pollution of water.** This has a harmful effect on the aquatic organisms, such as fishes and algae. The increase in temperature of river water also decreases the level of dissolved oxygen, which results in the release of foul and toxic gases.

Effects of Water Pollution

The pollution of fresh and marine water has harmful effects on the environment, human health and other organisms. Effects of different Sources of water pollution can be discussed as under:

The **domestic waste and sewage** has the following effects:

- It can cause infectious diseases, such as typhoid, cholera, dysentery, jaundice, etc.
- The presence of pathogens make it unfit for domestic use.
- The reduced oxygen level causes foul smell.

The **industrial wastes** have the following effects:

- The water cannot be used for domestic purposes.
- It has caused extinction of a number of marine species.
- It includes toxic metals (lead, mercury, zinc, copper, cadmium and chromium) and toxic non-metals (arsenic, petrochemicals, acids, alkalis) whose effects can be:

    1. The accumulation of **lead** in human body damages the nervous system, kidney, liver and brain. The children and pregnant women are most affected by lead poisoning.
    2. **Mercury** and its compounds can cause abdominal problems, headache, chest pain and diarrhea.
    3. **Zinc** can cause renal damage and vomiting.
    4. **Copper** can cause hypertension, dizziness and drowsiness.
    5. The accumulation of **chromium** can cause diseases like cancer and disorder of nervous system.
    6. **Arsenic** can cause liver cirrhosis, lung cancer, kidney damage, gastrointestinal disorder and skin problems.

The **agricultural wastes** have the following effects:

- The water becomes turbid due to suspended impurities and is unfit for domestic use.
- It causes respiratory and vascular damage by restricting the amount of oxygen that reaches the brain.
- It can cause precipitation of proteins in the body resulting in the damage of the liver.
- It reacts with respiratory system and causes acute suffocation by blocking the respiratory tract.

The **marine pollution** has the following effects:

- The nuclear wastes are disposed off in sealed containers in the deep seas. The leakage can cause serious damage to flora and fauna in marine habitat.
- Oil spills cause frequent death of plankton, fish, coral reef, sea food and marine birds. The oil spreads on water and forms a layer, which is harmful for marine life. Some chemicals in the oil form a black layer on the surface which can coat the feathers of birds and fur of marine mammals. All of them die or drown. When the oil spill reaches the coast, it affects fishing activities and tourism.

Fresh Water Depletion and Contamination

Fresh water is naturally occurring water on Earth's surface in ice sheets, ice caps , glaciers, icebergs, bogs, ponds, lakes, rivers and streams, and underground as groundwater in aquifers and underground streams. Fresh water is generally characterized by having low concentrations of dissolved salts and other total dissolved solids.

Global freshwater consumption rose six-fold in the last century, at more than twice the rate of population growth. Yet for many of the world's poor, one of the greatest environmental threats to health remains lack of access to safe water and sanitation. Over 1 billion people globally lack access to safe drinking-water supplies, while 2.6 billion lack adequate sanitation; diseases related to unsafe water, sanitation and hygiene result in an estimated 1.7 million deaths every year

Poor access to sufficient quantities of water also can be a key factor in water-related disease, and is closely related to ecosystem conditions. About one-third of the world's population lives in countries with moderate to high water stress, and problems of water scarcity are increasing, partly due to ecosystem depletion and contamination. Two out of every three persons on the globe may be living in water-stressed conditions by the year 2025, if present global consumption patterns continue.

Water ecosystems both replenish and purify water resources essential to human health and well-being. But the sustainability of many such ecosystems has been impacted by development and land use changes involving: elimination of marshes and wetlands; the diversion of surface water or alteration of flows; increased exploitation of underground aquifers; and contamination of water by waste and discharges from industry and transport, as well as from household and human waste.

The absolute quantity and the diversity of pollutants reaching freshwater systems have increased since the 1970s. These include not only biological contaminants, e.g. microorganisms responsible for traditional water-borne diseases, but also heavy metals and synthetic chemicals, including fertilizers and pesticides. Depending on the type of contaminant and degree of exposure, acute or chronic health impacts may result, along with impacts on the environment.

Eutrophication

One of the main problems affecting coastal waters is the high levels of nitrogen and phosphorous based pollutants entering the water. These pollutants come mainly from human activities. Excessive discharge of nutrients into coastal water results in accelerated phytoplankton growth. Eutrophication is defined as '**enhanced plankton growth due to excess supply of nutrients**'. Large growths of phytoplankton are known as blooms and these large blooms can have undesirable effects.

Major problems associated with eutrophication are:

- These blooms occur throughout the water and prevent light reaching the waters below. This stops the growth of plants deeper in the water and reduces biological diversity.
- When the blooms are really large, this bacterial decomposition can use up so much oxygen in the deep waters that there isn't enough left for fish to breathe and they have to swim away or else they die. Animals living on

Biological oxygen demand (BOD) is the amount of dissolved oxygen needed (i. e., demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. BOD can be used to gauge the effectiveness of wastewater treatment plants. Pristine rivers, where there is very little microbial growth have very less values of BOD (~1mg/L); untreated sewerage, which has high nutrients, and therefore, supports high micro-organism growth, has values ranging from 200-600mg/L.

P.S. - Dissolved oxygen depletion is most likely to become evident during the initial aquatic microbial population explosion in response to a large amount of organic material. If the microbial population deoxygenates the water, however, that lack of oxygen imposes a limit on population growth of aerobic aquatic microbial organisms resulting in a longer term food surplus and oxygen deficit.

the sea floor can't easily move away and they also die.

- Excess nutrients can sometimes encourage the growth of phytoplankton species which produce harmful toxins. These toxins may cause the death of other species including fish in fish farms.
- Large phytoplankton blooms can cause huge ugly foams on beaches. These blooms are not toxic but temporarily ruin the beach, reducing its recreational value.

Remedial Measures

1. **Sewage treatments:** Adequate care should be taken to ensure that effective sewage treatment process is in place and that contaminated water does not get mixed with the environment. In order to prevent water pollution, human and animal excreta should be prevented from mixing with its sources. Construction of pit toilet and proper sewage treatments can offer some solution to this problem.

   Sewage contains large amounts of organic matter and microbes. Many of which are pathogenic. Treatment of waste water is done by the heterotrophic microbes naturally present in the sewage. This treatment is carried out in two stages:

   Primary treatment: These treatment steps basically involve **physical removal of particles-** large and small- from the sewage through filtration and sedimentation. These are removed in stages; initially, floating debris is removed by sequential filtration. Then the grit (soil and small pebbles) are removed by sedimentation. All solids that settle form the **primary sludge,** and the supernatant forms the effluent. The effluent from the primary settling tank is taken for secondary treatment.

   Secondary treatment or Biological treatment: The primary effluent is passed into large aeration tanks where it is constantly agitated mechanically and air is pumped into it. This allows vigorous growth of useful aerobic microbes into **flocs** (masses of bacteria associated with fungal filaments to form mesh like structures). While growing, these microbes consume the major part of the organic matter in the effluent. This significantly reduces the **BOD (biochemical oxygen demand)** of the effluent. BOD refers to the **amount of the oxygen that would be consumed if all the organic matter in one litre of water were oxidised by bacteria**. The sewage water is treated **till** the BOD is reduced. The **BOD test measures the rate of uptake of oxygen by micro-organisms in a sample of water** and thus, indirectly, BOD is a measure of the organic matter present in the water. Greater the BOD of waste-water, more is its polluting potential.

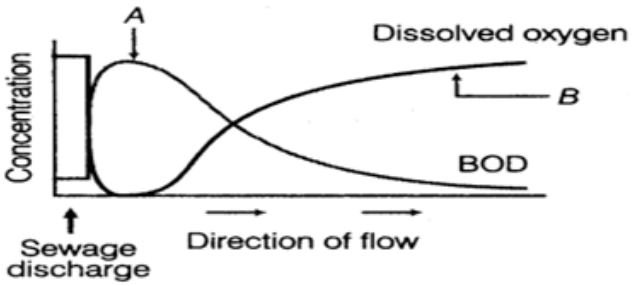
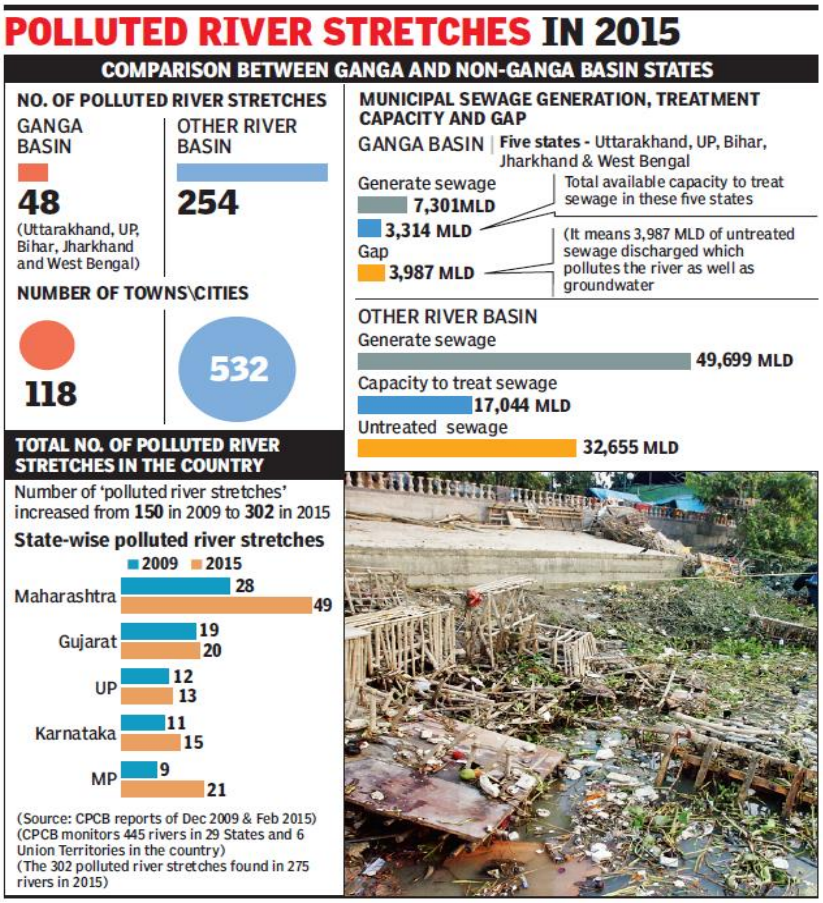
   

   Figure depicting effect of sewage on river

   Once the BOD of sewage or waste water is reduced significantly, the effluent is then passed into a settling tank where the bacterial 'flocs' are allowed to sediment. This sediment is called **activated sludge.** A small part of the activated sludge is pumped back into the aeration tank to serve as the inoculum. The remaining major part of the sludge is pumped into large tanks called **anaerobic sludge digesters.** Here, other kinds of bacteria, which grow anaerobically, digest the bacteria and the fungi in the sludge. During this digestion, bacteria produce a mixture of gases such as **methane, hydrogen sulphide and carbon dioxide**. These gases form **biogas** and can be used as source of energy as it is inflammable. The effluent from the secondary treatment plant is generally released into natural water bodies like rivers and streams.
2. **Prevent river water to get polluted:** The flowing water of the river cannot be cleaned easily by natural process. Since, a large number of external substances are discharged into the water, the river water becomes polluted. This may cause diseases to the people using river water. Thus, every effort should be made to prevent the river water to get contaminated. People should not be allowed to throw wastes into the river water.
3. **Treatment of wastes before discharge:** Factories are expected to treat its effluent wastes prior to discharge. Toxic material must be treated chemically and converted into harmless materials. If possible, factories should try to recycle the treated water**.**
4. **Strict adherence to water laws:** Laws and legislation relating to pollution should be strictly followed by all. People should be made aware that adherence to water laws is in their own interest.

5. **Treatment of drainage water:** In cities, a huge amount of water is put into drains every day. The water that flows through the city drainage system should be properly treated. Harmful pollutants be removed, before they are introduced into reservoirs. If this water allowed going into water reservoirs without treatment, it will pollute them.
6. **Keep the pond water clean and safe:** Washing, bathing of cattle in the pond that is used by human should not be done. Washing of dirty clothes and bathing of cattle make the pond water dirty and unsuitable for human use. If these ponds are continually misuses, then it may lead of severe consequences.
7. **Routine cleaning:** Ponds, lakes and wells meant for human use should be routinely cleaned and treated, so that it remains fit for human use. It is an essential step that should not be avoided. A system of regular testing of pond and lake water can be introduced to ensure the safety of the water.



8. **Don't pour insecticides in sinks and toilets:** Never pour household insecticides, medicines, etc. down the sink, drain or toilet. At homes, people often throw wastes and old medicines into the bathroom toilet. This practice is discouraged for the reason that the chemical compounds of medicines, insecticides, etc., when mixed with other chemicals, may result in formation of harmful substances.
9. **Public Awareness:** Common public should be aware about the effect of water pollution. Voluntary organization should go door-to-door to educate the creating awareness about the environment. They should run environmental education centers. Students can impart health education to enable people to prevent water pollution.

Naturally decontaminating water

The cleaning occurs in two stages. Firstly, the conventional sedimentation, filtering and chlorine treatments are given. After this stage, lots of dangerous pollutants like dissolved heavy metals still remain. This water is then passed through large marshy area containing appropriate plants, algae, fungi and bacteria which neutralise, absorb and assimilate the pollutants. Hence, as the water flows through the marshes it gets purified naturally.

The process of using **fungal mycelia** to filter toxic waste and microorganisms from water in soil is called **Mycofiltration**. Similarly use of plants to eliminate toxic waste from the water or other polluted medium is called **phytoremediation**. Many plants such as **mustard plants, alpine pennycress, hemp, and pigweed** have proven to be successful at **hyperaccumulating** contaminants at toxic waste sites.

For **bioremediation,** read ahead.

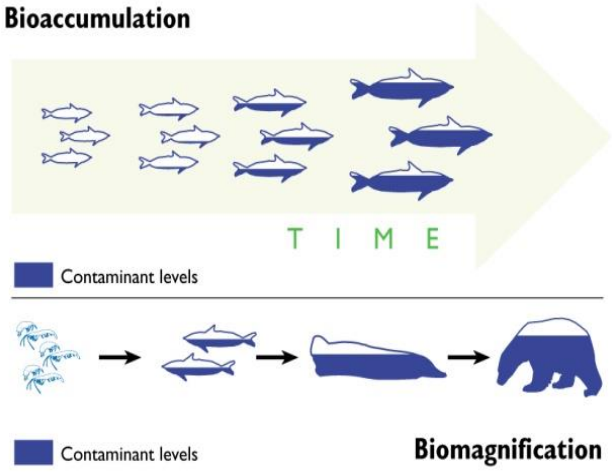
Chlorine, Chloramine, Chlorine dioxide, Ozone and UV rays are commonly used as water disinfectant.

Bioamagnification, Bioaccumulation and Bioconcentration

Biomagnification (or Bioamplification) refers to an increase in the concentration of a substance as you move up the food chain. This often occurs because the pollutant is persistent, meaning that it cannot be, or is very slowly, broken down by natural processes. These persistent pollutants are transferred up the food chain faster than they are broken down or excreted.

In contrast, bioaccumulation occurs within an organism, where a concentration of a substance builds up in the tissues as it is absorbed faster than it is removed. Bioaccumulation often occurs in two ways, simultaneously: by eating contaminated food, and by absorption directly from water. This second case is specifically referred to as bioconcentration.

For example: phytoplankton and other microscopic organisms take up methylmercury and then retain it in their tissues. Here, mercury bioaccumulation is occurring: mercury concentrations are higher in the organisms than it is in the surrounding environment. As animals eat these smaller organisms, they receive their prey's mercury burden. Because of this, animals that are higher in the food chain have higher levels of mercury than they would have due to regular exposure. With increasing trophic level, mercury levels are amplified.



5.9.3. POLLUTION DUE TO SOLID WASTES

All waste that we generate can be categorized into three types – ***bio-degradable, recyclable and the non-biodegradable*.** Solid wastes are generally composed of non-biodegradable and non-compostable biodegradable materials. The latter refer to solid wastes whose bio-deterioration is not complete; in the sense that the enzymes of microbial communities that feed on its residues cannot cause its disappearance or conversion into another compound.

Solid waste pollution is when the environment is filled with non-biodegradable and non-compostable biodegradable wastes that are capable of emitting greenhouse gases, toxic fumes, and particulate matters as they accumulate in open landfills. These wastes are also capable of leaching organic or chemical compositions to contaminate the ground where such wastes lay in accumulation. The concentration of solid wastes reacting to heat, moistures and air as they lay exposed to the environment also cause greenhouse gas emissions.

Irreparable computers and other electronic goods are known as **electronic wastes** (e-wastes). E-wastes are buried in landfills or incinerated. Over half of the e-wastes generated in the developed world are exported to developing countries, mainly to China, India and Pakistan, where metals like copper, iron, silicon, nickel and gold are recovered during recycling process. Unlike developed countries, which have specifically built facilities for recycling of e-wastes, recycling in developing countries often involves manual participation thus exposing workers to toxic substances present in e-wastes. Recycling is the only solution for the treatment of e-waste, provided it is carried out in an environment friendly manner.

The e-waste substances found in large quantities include epoxy resins, fiberglass, PCBs, PVC (polyvinyl chlorides), thermosetting plastics, lead, tin, copper, silicon, beryllium, carbon, iron and aluminium. Elements found in small amounts include cadmium, mercury, and thallium. Other elements are also present in trace amounts.

Remedial Measures

Burning is often used to treat the municipal solid waste. Burning reduces the volume of wastes, although it is generally not burn to completion and open dumps often serve as the breeding ground for rats and flies. **Sanitary landfills** adopted as the substitute for open-burning dumps. In a sanitary landfill wastes are dumped in a depression or trench after compaction and covered with dirt every day. Landfills are also not really much of a solution since the amount of garbage generation especially in the metros has increased so much that these sites are getting filled too. Also there is danger of seepage of toxic chemicals to the underground water resources.

A solution to all this can only be in human beings becoming more sensitive to environment issues. All waste should be sorted into three types (a) bio-degradable, (b) recyclable and (c) the non-biodegradable. What can be reused or recycled should be separated. The biodegradable materials can be put into deep pits in the ground and be left for natural breakdown. That leaves only the non-biodegradable to be disposed-off. The need to reduce our waste generation should be a priority and use of recyclable and biodegradable materials wherever possible be encouraged.

Regulation of E-Waste in India

As per the survey carried out by Central Pollution Control Board (CPCB) during the year 2005, 1,46,800 MT of e-waste was generated in the country. The Ministry of Environment & Forests has notified e-waste (Management and Handling) Rules, 2011 which have become effective from 1st May, 2012. These Rules provide for mandatory authorization of producer, collection center, dismantler and recycler of e-waste; registration of dismantler and recycler of e-waste from the State Pollution Control Board or Pollution Control Committee of Union territories; and '**Extended Producer Responsibility**' under which producers will be responsible for collection and channelization of e-waste generated from the 'end of life' of their products to registered dismantler or recycler.

Import and export of e-waste are regulated under Hazardous Waste (Management, Handling and Trans-boundary Movements) Rules, 2008. Under the Rules no permission for import of e-waste has been granted during last three years by the Ministry of Environment and Forests. However, permission for export of 10,575 MT of e-waste has been granted for export of e-waste to various countries viz. Belgium, Germany, Japan, Singapore Hong Kong, Sweden, UK and Switzerland.

5.9.4. RADIATION POLLUTION

Radiation, that is given off by nuclear waste is extremely damaging to organisms, because it causes mutations at a very high rate. At high doses, nuclear radiation is lethal but at lower doses, it creates various disorders, the most frequent of all being cancer. Therefore, nuclear waste is an extremely potent pollutant and has to be dealt with utmost caution.

The natural sources of radiation pollution include cosmic rays, ultraviolet rays and infra-red rays, which reaches the earth from the sun and other heavenly bodies. It also includes radioactive rays from unstable atoms of uranium, thorium and radium. The human-made radiations come from the use of radioactive materials, which are widely used in the production of nuclear weapons, nuclear fuel and electric power.

It has been recommended that storage of nuclear waste, after sufficient pre-treatment, should be done in suitably shielded containers buried within the rocks, about 500 m deep below the earth's surface.

Soil Pollution

Soil pollution is defined as the change in the physical, chemical and biological conditions due to the presence of various toxic materials. Harmful substances are added to the soil through the surface run-off or through leaching. Soils can be polluted by pathogenic organisms, organic and inorganic chemicals and toxic metals. Some of the toxic chemicals from the polluted soils may enter the food chain and then enter the body of humans and other organisms, causing serious health problems.

Sources of Soil Pollution

- Industrial effluents like harmful gases and chemicals.
- Use of chemicals in agriculture like pesticides, fertilizers and insecticides.
- Improper or ineffective soil management system.
- Unfavorable irrigation practices, especially over-irrigation.
- Improper management and maintenance of septic system, sanitary waste leakage, release sewage into dumping grounds and nearby water bodies.
- Toxic fumes from industries get mixed with rains causing acid rains.
- Leakages of fuel from automobiles are washed off due to rains and are deposited in the nearby soil.
- Use of pesticides in agriculture retains chemicals in the environment for a long time. These chemicals also effect beneficial organisms like earthworm in the soil and lead to poor soil quality.
- Garbage blocks passage of water into the soil and affects its water holding capacity.
- Unscientific disposal of nuclear waste contaminate soil and can cause mutations.

Consequences of soil pollution

Soil pollution causes huge disturbances in the ecological balance and health of living organisms at an alarming rate. Some the effects of soil pollution are:

- Reduced soil fertility causes decrease in agricultural yield.

- Loss of natural nutrients in soil.
- Reduced nitrogen fixation.
- Increased soil erosion.
- Imbalance in the flora and fauna of the soil.
- Increase in soil salinity, makes it unfit for cultivation.
- Creation of toxic dust.
- Foul odor due to industrial chemicals and gases.
- Alteration in soil structure can lead to death of organisms in it.

Remedial Measures

- Reducing the use of chemical fertilizer and pesticides.
- Recycling paper, plastics and other materials.
- Ban on use of plastic bags, which are a major cause of pollution.
- Reusing materials.
- Avoiding deforestation and promoting forestation.
- Suitable and safe disposal of wastes including nuclear wastes.
- Chemical fertilizers and pesticides should be replaced by organic fertilizers and pesticides.
- Encouraging social and agro forestry programs.
- Undertaking many pollution awareness programs.
- Bioremediation

Bioremediation

It is a treatment that uses naturally occurring organisms to break down hazardous substances into less toxic or non-toxic substances. It uses microorganisms to degrade organic contaminants in soil, groundwater, sludge, and solids. The microorganisms break down contaminants by using them as an energy source or cometabolizing them with an energy source. When Fungi are used, it is called mycoremediation. Bioremediation may be conducted *in situ* or *ex situ*.

It has been relied up on to clean oil spills in the recent past using the bacteria of family *Pseudomonas* and other bacteria like Alcanivorax or Methylocella Silvestris.

Not all contaminants are easily treated by bioremediation using microorganisms. For example, heavy metals such as cadmium and lead are not readily absorbed or captured by microorganisms. Phytoremediation is useful in these circumstances because plants are able to bioaccumulate these toxins in their above-ground parts, which are then harvested for removal.

Genetic engineering has been used to create organisms designed for specific purposes. For e.g. bacterium *Deinococcus radiodurans* (the most radioresistant organism known) has been modified to consume and digest toluene and ionic mercury from highly radioactive nuclear waste. However, releasing GM organisms into the environment may be problematic as tracking them can be difficult; bioluminescence genes from other species may be inserted to make this easier.

5.9.5. NOISE POLLUTION

Sound, which is measured in decibels (dB), is a form of energy having wave motion. Any sound, which is unwanted or unpleasant to our ears, is called noise. Thus any undesirable sound which adversely affects the physical and mental health of its recipient is called noise pollution. The noise pollution can be due to natural processes or human activities. It is caused by industries, mining, transport vehicles, thunder, households, defence sector, loudspeakers, supersonic jet aircrafts and others. Loud noise can cause impairment of hearing or total deafness.

Consequences

- Hearing impairment.
- It causes anxiety and stress reaction and in extreme cases, fright.
- There is increase in heart rate.
- Increase in cholesterol and blood pressure due to constriction of blood vessels.
- Stomach disorders and digestive spasm.

- Dilation of pupil of the eye.
- It also interferes with peace of mind, behaviour and proper communication.
- Nervousness, headache, irritability, fatigue and decrease in work efficiency can be caused due to noise pollution.
- It also affects the development of embryo in mother's womb.
- Effects on Wildlife: It can lead to changes in the delicate balance in predator and prey detection, interferes with the sounds of communication and in the relations to reproduction and navigation and overexposure to noise can lead to temporary or permanent loss of hearing.

Green Mufflers are barriers grown near noisy places to reduce the impact of noise. Normally 4 to 5 rows of green plants are grown near the noisy places like highways or industrial areas so that they obstruct the sound noise.

NATIONAL AND INTERNATIONAL CONVENTIONS

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6. NATIONAL AND INTERNATIONAL CONVENTIONS

6.1. INTRODUCTION

The importance of international cooperation across a diversity of topics is increasingly recognized. An ever more interconnected world demands multilateral approaches to trade, security, migration, and a host of other issues. In the environmental context, in particular, there is an appreciation that environmental degradation is often a global problem and, as such, requires global responses. The depletion of the ozone layer, loss of biodiversity and spread of persistent organic pollutants, for instance, resulted from human activity in countries around the world and have impacts that extend far beyond national borders. As a result, domestic conservation and environmental management strategies alone are insufficient to conserve shared natural resources and safeguard the global ecosystem. International cooperation is not only fundamental; it has also been recognized as the best and most effective way for governments to tackle trans-boundary or global environmental problems.

The growth of international concern to protect migratory wild life, marine animals and fisheries started during 1872 itself i.e. a century before Stockholm conference but due to the absence of institutional machinery, treaties proved to be not so effective. The machinery that was chosen for international concern was a group of private citizens i.e., the non-governmental congress for protection of nature.

The environment has always been critical to life but concerns over the balance between human life and the environment assumed international dimensions only during the 1950's.The 1970's was the foundation of *modern environmentalism*. It was for the first time when various countries for the first time came together to discuss the concerns of environmental pollution, global warming and threat to ozone layer.

The principle of common but differentiated responsibilities is elaborated in the Rio Declaration: *"States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command."*

In light of the principle of common but differentiated responsibilities, MEAs[1] seek to address environmental problems in a balanced and equitable manner, acknowledging the different contribution of countries to the causes of environmental problems and their diverse capacities to resolve them. To accomplish this, each MEA contains different sets of measures intended to complement and support each other, typically with provisions establishing regulatory parameters.

6.2. INTERNATIONAL CONVENTIONS AND TREATIES

International environmental policies are in the form of treaties, multilateral agreements, conventions and conferences. An overview of some of the major multilateral agreements, treaties and conventions on environment obligations are discussed below:

6.2.1. 1971: CONVENTION ON WETLANDS OF INTERNATIONAL IMPORTANCE, ESPECIALLY AS WATERFOWL HABITAT ("RAMSAR CONVENTION")

The Ramsar Convention is an international treaty for the conservation and sustainable utilization of wetlands, i.e. to stem the progressive encroachment on and loss of wetlands now and in the future, recognizing *the fundamental ecological functions of wetlands and their economic, cultural, scientific, and recreational value*. The Ramsar Convention is the only global environmental treaty that deals with a particular ecosystem. The treaty was adopted in the *Iranian city of Ramsar in 1971* and the Convention's member countries cover all geographic regions of the planet. The Convention uses a broad definition of the types of wetlands covered in its mission, including lakes and rivers, swamps and marshes, wet grasslands and peat lands, oases, estuaries, deltas and tidal flats, near-shore marine areas, mangroves and coral reefs, and human-made sites such as fish ponds, rice paddies, reservoirs, and salt pans.

[1] Multilateral Environmental Agreements

6.2.2. 1972: STOCKHOLM DECLARATION

The United Nations Conference on the *human environment* held at Stockholm on 5th and 6th June 1972, generally called as the Stockholm Conference, was the *first declaration of international protection* of the environment. In the conference, 113 States, including India, participated and accepted the declaration. The Stockholm Declaration contains 26 principles. These principles provide the basis of an International Policy for the Protection and improvement of the environment. *The United Nations Environment Programme has been established by the United Nations General Assembly in pursuance of the Stockholm Conference.* The UNEP worked as catalyst stimulator and coordinator among the member states on the environmental action.

6.2.3. 1973: CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES OF WILD FLORA AND FAUNA (CITES)

The Conference aimed to *control or prevent international commercial trade in endangered species or products derived from them*. The Convention did not seek to directly protect endangered species, rather it aimed to reduce the economic incentive to poach endangered species and destroy their habitat by closing off the international market.

6.2.4. 1979: CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

The convention opened for signature in 1979 and entered into force in 1983. The aim of the Convention is that Parties shall endeavour to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution. Parties develop policies and strategies to combat the discharge of air pollutants through exchanges of information, consultation, research and monitoring. It is implemented by the European Monitoring and Evaluation Programme (EMEP), directed by the United Nations Economic Commission for Europe (UNECE). India is not a part of this convention.

6.2.5. 1982: NAIROBI DECLARATION

The Nairobi Declaration was adopted at Nairobi for celebrating the 10th Anniversary of the Stockholm conference on human Environment in 1972. The Declaration envisaged the creation of a special commission to frame long term environment strategies for achieving sustainable developments upto the year 2000 and beyond. The Declaration was endorsed by the governing Council of United Nations Environment Programme (UNEP) in 1987.

6.2.6. 1985: VIENNA CONVENTION FOR THE PROTECTION OF OZONE LAYER

The Vienna Convention was adopted in 1985. It became an important legal basis for taking international action to protect the Earth's stratospheric ozone layer. Among the objectives set out in the Convention is for Parties to promote cooperation by means of systematic observations, research and information exchange on the effects of human activities on the ozone layer and to adopt legislative or administrative measures against activities likely to have adverse effects on the ozone layer.

6.2.7. 1987: MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

The Montreal Protocol is an international treaty designed *to protect the ozone layer by phasing out the production of a number of substances believed to be responsible for ozone depletion.* The treaty is structured around several groups of *halogenated hydrocarbons* that have been shown to play a role in ozone depletion. All of these ozone depleting substances contain either chlorine or bromine (substances containing fluorine-only do not harm the ozone layer). The treaty was opened for signature in 1987 and entered into force in 1989. Since then, it has undergone five revisions, in 1990 (London), 1992 (Copenhagen), 1995 (Vienna), 1997 (Montreal), and 1999 (Beijing).In a major innovation the protocol recognized that all nations should not be treated equally. The agreement acknowledges that certain countries have contributed to ozone depletion more than others. It also recognizes that a nation's obligation to reducecurrent emissions should reflect its technological and financial ability to do so.

6.2.8. 1987: OUR COMMON FUTURE: REPORT OF THE WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT ("BRUNDTLAND REPORT")

The concept of 'sustainable development' was crystallized in the 1987 report of the United Nations World Commission on Environment and Development - *The Brundtland Commission* - which drew upon long established lines of thought that had developed substantially over the previous 20 years. The Brundtland Commission's characterization of 'sustainable development' is *development that meets the needs of the present without compromising the ability of future generations to meet their own needs.* The prominence given to 'needs' reflects a concern to eradicate poverty and meet basic human needs, broadly understood. The concept of sustainable development focused attention on finding strategies to promote economic and social development in ways that avoided environmental degradation, over-exploitation or pollution, and sidelined less productive debates about whether to prioritize development or the environment.

6.2.9. 1989: BASEL CONVENTION ON THE CONTROL OF TRANSBOUNDARY MOVEMENTS OF HAZARDOUS WASTES AND THEIR DISPOSAL

It is an international treaty that was designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries (LDCs). It does not, however, address the movement of radioactive waste. The Convention is also intended to minimize the amount and toxicity of wastes and to assist LDCs in environmentally sound management of the hazardous and other wastes they generate.

6.2.10. 1992: AGENDA 21

Agenda 21 is a comprehensive blueprint of action to be taken globally, nationally and locally by organisations of the UN, governments, and major groups in every area in which humans affect the environment. The number 21 refers to the 21st century. *The full text of Agenda 21 was revealed at the 1992 United Nations Conference on Environment and Development (UNCED / "Earth Summit"),* held in Rio de Janeiro on 14 June 1992 where 179 governments voted to adopt the program. The implementation of Agenda 21 was intended *to involve action at international, national, regional and local levels.* In 1997, the General Assembly of the UN held a special session to appraise five years of progress on the implementation of Agenda 21 (+5). ***The Johannesburg Plan of Implementation, agreed at the World Summit on Sustainable Development (Earth Summit 2002)*** affirmed UN commitment to 'full implementation' of Agenda 21, alongside achievement of the Millennium Development Goals and other international agreements.

6.2.11. 1992: FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

The UNFCCC is an international environmental treaty produced at the *Earth Summit in 1992.* The treaty aims at reducing emissions of greenhouse gas in order to combat global warming. Its stated objective is *"to achieve stabilization of greenhouse gas concentrations in the atmosphere at a low enough level to prevent dangerous anthropogenic interference with the climate system."* The treaty as originally framed set no mandatory limits on greenhouse gas emissions for individual nations and contained no enforcement provisions; it is therefore considered *legally non-binding*. Rather, the treaty included provisions for updates (called "protocols") that would set mandatory emission limits. The principal update is the **Kyoto Protocol**, which has become much better known than the UNFCCC itself. The treaty was opened for signature in 1992 and entered into force in 1994.

6.2.12. 1992: CONVENTION ON BIOLOGICAL DIVERSITY

The Convention on Biological Diversity is an international treaty that was adopted at the Earth Summit in 1992. The Convention has three main goals:

1. Conservation of biological diversity (or biodiversity);
2. Sustainable use of its components;
3. Fair and equitable sharing of benefits arising from genetic resources.

In other words, its objective is to develop national strategies for the conservation and sustainable use of biological diversity. The convention recognized for the first time in international law that the conservation of biological diversity is "a common concern of humankind" and is an integral part of the development process. The

agreement covers all ecosystems, species, and genetic resources. It links traditional conservation efforts to the economic goal of using biological resources sustainably. It sets principles for the fair and equitable sharing of the benefits. It also covers the rapidly expanding field of biotechnology through***Cartagena Protocol on Biosafety***, addressing technology development and transfer, benefit-sharing and biosafety issues. Importantly, the Convention is *legally binding*; countries that join it are obliged to implement its provisions.

6.2.13. 1997: PROTOCOL TO THE UNFCCC ("KYOTO PROTOCOL")

The Kyoto Protocol is an agreement made under the UNFCCC. Countries that ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases *(Methane, Nitrous Oxide, Sulphur Hexafluoride, Hydrofluorocarbons and Perfluorocarbons)*, or engage in *emissions trading* if they maintain or increase emissions of these gases. Under the protocol, Governments are separated into two general categories: **countries among the developed nations, referred to as *Annex 1 countries*** (who have accepted GHG emission reduction obligations and must submit an annual greenhouse gas inventory); and **countries among developing or least developed nations, referred to as *Non-Annex 1 countries*** (who have no GHG emission reduction obligations but may participate in the *Clean Development Mechanism*).The Kyoto Protocol could enter into force once it was ratified by 55 countries, including countries responsible for 55 per cent of the developed world's 1990 carbon dioxide emissions.

By 2008-2012, Annex 1 countries have to reduce their GHG emissions by an average of 5% below their 1990 levels (for many countries, such as the EU member states, this corresponds to some 15% below their expected GHG emissions in 2008). While the average emissions reduction is 5%, national targets range from 8% reductions for the European Union to a 10% emissions increase for Iceland. Reduction targets expired in 2013. Kyoto Protocol includes "flexible mechanisms" which allow Annex 1 economies to meet their GHG targets by purchasing GHG emission reductions from elsewhere. These can be bought either from financial exchanges (*International Emissions TradingScheme*) or from projects which reduce emissions in non-Annex 1 economies under the *Clean Development Mechanism* (CDM), or in other Annex-1 countries under the *Joint Implementation* (JI).

Only CDM Executive Board-accredited *Certified Emission Reductions* (CER) can be bought and sold in this manner. Under the aegis of the UN, Kyoto established this Bonn-based Clean Development Mechanism Executive Board to assess and approve projects (“CDM Projects”) in Non-Annex 1 economies prior to awarding CERs. (A similar scheme called “*Joint Implementation*” or “JI” applies in transitional economies mainly covering the former Soviet Union and Eastern Europe).The Protocol entered into force in 2005.

In Doha, Qatar, on 8 December 2012, the "Doha *Amendment to the Kyoto Protocol*" was adopted.[2] During the first commitment period, 37 industrialized countries and the European Community committed to reduce GHG emissions to an average of five percent against 1990 levels. During the second commitment period, Parties committed to reduce GHG emissions by at least 18 percent below 1990 levels in the eight-year period from 2013 to 2020; however, the composition of Parties in the second commitment period is different from the first. Belarus, Cyprus, Kazakhstan, Malta are the country added to Annex B[3] to the Kyoto Protocol. While Canada, Japan, New Zealand, Russia, USA are out of the Annex B list.

6.2.14. 1998: ROTTERDAM CONVENTION

The objectives of the Rotterdam Convention are: to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm; and to contribute to the environmentally sound use of those hazardous chemicals, by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to Parties. The Convention creates legally binding obligations for the implementation of the *Prior Informed Consent (PIC)* procedure. The Rotterdam Convention was adopted in 1998 and entered into force in 2004.

[2] For detailed amendments to the Kyoto Protocol, refer COP 18 reference, later in the notes.

[3] Annex B lists party quantified emission limitations or reduction commitments.

6.2.15. 2000: THE CARTAGENA PROTOCOL ON BIOSAFETY ("CARTAGENA PROTOCOL")

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international agreement which aims to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity, taking also into account risks to human health. It was adopted on 29 January 2000 and entered into force on 11 September 2003. It establishes an *advance informed agreement* (AIA) procedure for ensuring that countries are provided with the information necessary to make informed decisions before agreeing to the import of such organisms into their territory. The Protocol also establishes a *Biosafety Clearing-House* to facilitate the exchange of information on living modified organisms and to assist countries in the implementation of the Protocol.

6.2.16. 2001: CONVENTION ON PERSISTENT ORGANIC POLLUTANTS ("STOCKHOLM CONVENTION")

The Stockholm Convention is an international legally binding agreement on persistent organic pollutants. *Persistent organic pollutants (POPs)* are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bio accumulate in human and animal tissue, bio magnify in food chains, and to have potential significant impacts on human health and the environment. *Intergovernmental Forum on Chemical Safety* (IFCS) and the *International Programme for Chemical Safety* (IPCS) prepared a list, known as the *Dirty Dozen*, including *eight organochlorine pesticides: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex and toxaphene; two industrial chemicals: hexachlorobenzene (HCB) and the polychlorinated biphenyl (PCB) group; and two groups of industrial by-products: dioxins and furans*. The convention entered into force in 2004. Co-signatories agree to outlaw nine of the "dirty dozen" chemicals, limit the use of DDT to malaria control, and curtail inadvertent production of dioxins and furans.

6.2.17. 2010: THE NAGOYA PROTOCOL

It is an international agreement which aims at sharing the benefits arising from the utilization of genetic resources in a fair and equitable way, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding, thereby contributing to the conservation of biological diversity and the sustainable use of its components. It was adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting on 29 October 2010 in Nagoya, Japan.

The fair and equitable sharing of the benefits arising out of the utilization of genetic resources is one of the three objectives of the Convention on Biological Diversity. The Strategic Plan consists of 20 new biodiversity targets for 2020, termed the '*Aichi Biodiversity Targets*[4]'. Official decisions on an indicator set to measure progress towards the Aichi Biodiversity Targets will help cement the role the Partnership will play in supporting the CBD.

6.2.18. 2013: MINAMATA CONVENTION ON MERCURY

An international treaty designed to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds. The Convention is named after the Japanese city Minimata. This naming is of symbolic importance as the city went through devastating incident of mercury poisoning. It is expected that over the next few decades, this international agreement will enhance the reduction of mercury pollution from the targeted activities responsible for the major release of mercury to the immediate environment.

6.3. RECENT DEVELOPMENT

6.3.1. UNITED NATIONS CLIMATE CHANGE CONFERENCE-CONFERENCE OF THE PARTIES (COP)

The United Nations Climate Change Conferences are yearly conferences held in the framework of the United Nations Framework Convention on Climate Change (UNFCCC). They serve as the formal meeting of the UNFCCC Parties (Conferences of the Parties) (COP) to assess progress in dealing with climate change, and beginning in the mid-1990s, to negotiate the Kyoto Protocol to establish legally binding obligations for developed countries to

[4]http://www.cbd.int/sp/targets/

reduce their greenhouse gas emissions. Also parties to the Convention that are not parties to the Protocol can participate in Protocol-related meetings as observers. The first conference was held in 1995 in Berlin. The Kyoto Protocol was signed in 1997 after the negotiations at COP 3.

COP13 in Bali (2007)

The Bali Road Map was adopted at the 13th Conference of the Parties and the 3rd Meeting of the Parties in December 2007 in Bali. The Bali Road Map includes the Bali Action Plan, which charts the course for a new negotiating process designed to tackle climate change. The Bali Action Plan aimed at (i) shared vision for long-term cooperative action, including a long-term global goal for emission reductions, (ii) enhanced national/ international action on mitigation of climate change, (iii) enhanced action on adaptation, (iv) enhanced action on technology development and transfer to support action on mitigation and adaptation, & (v) enhanced action on the provision of financial resources and investment to support action on mitigation and adaptation and technology cooperation. There was a strong consensus for updated changes for both developed and developing countries. Although there were not specific numbers agreed upon in order to cut emissions, the Decision recognized that there was a need for "deep cuts in global emissions" (plural countries proposed 100% reduction in 2050) and that "developed country emissions must fall 10-40% by 2020".

COP15 in Copenhagen (2009)

The Copenhagen Climate Change Conference raised climate change policy to the highest political level. It advanced many key issues like it raised climate change policy to the highest political level; it advanced the negotiations on the infrastructure needed for well-functioning, global climate change cooperation; It produced the *Copenhagen Accord*. The accord endorsed the continuation of the Kyoto protocol and emphasised a "strong political will to urgently combat climate change in accordance with the principle of common but differentiated responsibilities and respective capabilities". It was not adopted by all governments, but it advanced a number of key issues; and it committed developed countries to $30 billion fast-start financing (in 2010-2012) for adaptation and mitigation in developing countries, with priority given to the least developed countries.

COP16 in Cancun (2010)

The agreements encompassed finance, technology and capacity-building support to help such countries meet urgent needs to adapt to climate change, and to speed up their plans to adopt sustainable paths to low emission economies that could also resist the negative impacts of climate change. The Cancun Agreements main objectives covered *Mitigation* plans to establish clear goals and a timely schedule for reducing human-generated greenhouse gas emissions over time to keep the global average temperature rise below two degrees. It aimed at promoting t*ransparency of actions* and use of technology to boost efforts to address climate change. It also aimed to set up the *Green Climate Fund*[5] to provide support to developing countries to assist them in mitigating climate change and adapting to its impacts.

COP17 in Durban (2011)

In Durban, governments clearly recognized the need to draw up the blueprint for a fresh universal, legal agreement to deal with climate change beyond 2020. All governments committed in Durban to a comprehensive plan that would come closer over time to delivering the ultimate objective of the Climate Change Convention: to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent our dangerous interference with the climate system and at the same time will preserve the right to sustainable development.

Four main areas of coordinated and complementary action and implementation, designed also to build and preserve trust among countries, were agreed:

1) *Second commitment period of the Kyoto Protocol* - The continuation of the current international legal system through a second commitment period of the Kyoto Protocol till 2020.
2) *Launch of new platform of negotiations* - The launch of a new platform of negotiations under the Convention to deliver a new and universal greenhouse gas reduction protocol, legal instrument or other

[5]The Green Climate Fund (GCF) is a fund within the framework of the UNFCCC founded as a mechanism to transfer money from the developed to the developing world, in order to assist the developing countries in adaptation and mitigation practices to counter climate change. It will support projects, programmes, policies and other activities in developing country and is intended to be the centrepiece of efforts to raise Climate Finance of $100 billion a year by 2020.

outcome with legal force by 2015 for the period beyond 2020. This new negotiation critically includes finding ways to further raise the existing level of national and international action and stated ambition to bring greenhouse gas emissions down.

3) *Conclusion in 2012 of existing broad-based stream of negotiations* - A decision to conclude within 2012 the work of the existing broad-based stream of negotiations that includes all member nations under the Convention. This includes work to make existing national emission reduction or emission limitation plans more transparent. It also encompasses the launch and long-term implementation of the comprehensive global support network that will deliver funding and technology to help developing countries build their own clean energy futures and construct societies and economies which are resilient to climate change.
4) *Global Review* - To scope out and then conduct a fresh global review of the emerging climate challenge, based on the best available science and data, first to ensure whether a maximum two-degree rise is enough or whether an even lower 1.5 degree rise is required, and then to ensure that collective action is adequate to prevent the average global temperature rising beyond the agreed limit.

COP18 in Doha (2012)

Governments consolidated the gains of international climate change negotiations and opened a gateway to necessary greater ambition and action on all levels. The governments agreed to strengthen their resolve and set out a timetable to adopt a universal climate agreement by 2015, which will come into effect in 2020; to streamline the negotiations, completing the work under the Bali Action Plan to concentrate on the new work towards a 2015 agreement under a single negotiating stream in the Ad hoc Working Group on the Durban Platform for Enhanced Action (ADP); launched a new commitment period under the Kyoto Protocol.

Timetable for the 2015 global climate change agreement and increasing ambition before 2020 - So that the world has a chance to stay below an agreed maximum 2 degrees Celsius temperature rise, beyond which even more serious climate change impacts will occur, governments agreed to speedily work toward a universal climate change agreement covering all countries from 2020, to be adopted by 2015.

Amendment of the Kyoto Protocol - The Kyoto Protocol, as the only existing and binding agreement under which developed countries undertake quantitative commitments to cut greenhouse gases, was amended so that it could seamlessly continue.

1) Governments decided on an 8 year second commitment period that started on January 1st 2013.
2) The legal requirements that will allow a smooth continuation of the Protocol were agreed, and the valuable accounting rules of the Protocol were preserved.
3) Countries that are taking on further commitments under the Kyoto Protocol agreed to review their emission reduction commitments at the latest by 2014, with a view to increasing their respective levels of ambition.
4) The Kyoto Protocol's Market Mechanisms – the Clean Development Mechanism (CDM), Joint Implementation (JI) and International Emissions Trading (IET) – will continue.
5) Access to the mechanisms remains uninterrupted for all developed countries that have accepted targets for the second commitment period.
6) Surplus assigned amount units (AAUs) can be carried over without limit from the first to the second commitment period of the Kyoto Protocol by Parties included in Annex I that have a target for the second commitment period.

COP 18 endorsed the selection of the Republic of Korea as the host of *the Green Climate Fund (GCF)* and the work plan of the Standing Committee on Finance. The GCF was expected to start its work in Songdo in the second half of 2013. Developed countries reiterated their commitment to deliver on promises to continue *Long-term climate finance* support to developing nations, with a view to mobilizing USD 100 billion annually from a variety of sources both for adaptation and mitigation by 2020.

Governments would continue a work programme on long-term finance during 2013 to identify pathways for mobilizing scaled-up finance to reach the 100 billion target by 2020. Also, the Governments launched a robust process to review the long-term temperature goal, which is to start in 2013 and conclude by 2015, aimed at providing a reality check on the advance of the climate change threat and the possible need to mobilize further action.

COP19 in Warsaw (2013)

Governments took further essential decisions to stay on track towards securing a universal climate change agreement in 2015. The objective of the *2015 agreement* is twofold: ***First,*** to bind nations together into an effective global effort to reduce emissions rapidly enough to chart humanity's longer-term path out of the danger zone of climate change, while building adaptation capacity; ***second***, to stimulate faster and broader action. The governments decided to move towards a universal agreement that required monitoring, reporting and verification arrangements for domestic action have been finalized for implementation, thereby providing a solid foundation for the 2015 agreement, which will enter into force in 2020. The conference strengthened efforts to mobilize USD 100 billion by 2020. It was also decided to convene Ministerial meetings on long-term finance every two years for the period 2014-2020. Also, the rulebook for reducing emissions from deforestation and forest degradation was agreed, together with measures to bolster forest preservation and a results-based payment system to promote forest protection.

The framework for measuring, reporting and verifying mitigation efforts, including by developing countries, is now fully operational. It means that the mitigation, sustainability and support efforts of countries can now be better measured. This will also provide confidence to donors and investors who are potentially interested in financing nationally appropriate mitigation actions. The *Climate Technology Centre and Network (CTCN)*was established with an aim to stimulating technology cooperation and transfer to developing countries.

However, The G77 and China bloc led 132 poor countries in a walk out during talks about *"loss and damage*[6]*"* compensation for the consequences of global warming. Poor countries have demanded that the developed world give them $100 billion annually by 2020.
The **COP 20** will be held in 2014 at Lima, Peru.

COP 20 in Lima (2014)

Nations concluded the elements of the new agreement, scheduled to be agreed in Paris in 2015, while also agreeing the ground rules on how all countries can submit contributions to the new agreement called Intended Nationally Determined Contributions (INDCs). The INDCs combine the top-down system of a United Nations climate agreement with bottom-up system-in elements through which countries put forward their agreements in the context of their own national circumstances, capabilities and priorities, within the ambition to reduce global greenhouse gas emissions enough to keep global temperature rise to **2 degrees Celsius**.

The Lima Climate Conference achieved a range of other important outcomes:

- Pledges were made by both developed and developing countries prior to take the capitalization of the new Green Climate Fund (GCF) past an initial $10 billion target.
- Levels of transparency and confidence-building measures as several industrialized countries submitted themselves to questioning about their emissions targets under a new process called a Multilateral Assessment.
- The Lima Ministerial Declaration on Education and Awareness called on governments to put climate change into school curricula and climate awareness into national development plans.
- Recognition of National Adaptation Plans (NAPs) offers an important way of delivering climate change resilience.
- Executive Committee of the Warsaw International Mechanism on Loss and Damage was confirmed for two years with a balanced representation of members from developing and developed countries.
- Information hub to be launched on the UNFCCC web site, spotlighting actions by countries carrying out REDD+ activities.

COP21 in Paris (2015)

The conference negotiated the Paris Agreement on the reduction of climate change, the text of which represents a consensus of the representatives of the 196 parties attending it. The agreement will become legally binding if joined by at least 55 countries which together represent at least 55 percent of global greenhouse emissions.

[6] It is associated with the impacts of climate change in developing countries that are particularly vulnerable to the adverse effects of climate change. It aims that unless developed countries reduce their emissions significantly; the burden on the poor, vulnerable countries will further increase, leading to more loss and damage.

Such parties will need to sign the agreement and also adopt it within their own legal systems through ratification, acceptance, approval, or accession.

Important outcomes of the agreement are:

- It commits 196 countries to work together to limit global warming to no more than **2 degrees Celsius** above pre-industrial levels, with a stretch goal of keeping below **1.5 C**. It also calls for stopping the rise of greenhouse gas emissions as soon as possible.
- In **2018**, countries will take stock of their progress on meeting their pledges, and by 2020 they will have to produce new INDCs or restate the existing.
- The Paris Agreement is **not a treaty,** and countries' INDCs are not binding. Still, the deal contains some binding elements, such as requiring countries to participate in a system for measuring their progress on achieving their goals.The implementation of the agreement by all member countries together will be evaluated every 5 years.
- Finance will be provided to poor nations to help them cut emissions and cope with the effects of extreme weather. Countries affected by climate-related disasters will gain urgent aid.

The INDC commitments are voluntary, which means there is no penalty for failing to meet them. And even if they are met, they will not put the world on a path to less than 2 C of warming. Under the most optimistic assumptions, the INDCs still set us on a path to 2.7 to 3.5 C of warming. INDCs of rich countries are not enough to **meet their historical obligations**. Further, ingenious rights of people suffering due to activities like fossil fuel extraction are mentioned in the preamble, but left out entirely of the operational text. Hence, there has been debate on the desired success of the agreement.

International Agency for Solar Policy and Application (InSPA)
PM Modi announced at the 2015 G-20 Summit that he, along with French President François Hollande, intends to propose creating an alliance of solar-rich countries similar to the Organization of the Petroleum Exporting Countries (OPEC). Ahead of the climate summit, the two leaders sent written invitations to over 100 countries to join the coalition proposed to be called the International Agency for Solar Policy and Application (InSPA).

6.3.2. CONVENTION ON BIOLOGICAL DIVERSITY-CONFERENCE ON PARTIES

CBD COP 11 was held at Hyderabad, India in October 2012. It addressed issues such as capacity building, technology development and transfer, the adverse effects of climate change on developing and least developed countries, and several financial and budget-related issues, including guidelines to the Global Environment Facility (GEF), which serves as the Convention's financial mechanism. After lengthy negotiations, the COP also agreed on a process for considering future action beyond 2012 under the UNFCCC. Developed countries agreed to double funding to support efforts in developing states towards meeting the internationally-agreed Biodiversity Targets, and the main goals of the *Strategic Plan for Biodiversity 2011-2020*. It included new measures to factor biodiversity into environmental impact assessments linked to infrastructure and other development projects in marine and coastal areas.

The COP also set targets to increase the number of countries that have included biodiversity in their national development plans, and prepare national financial plans for biodiversity, by 2015. The 193 Parties to the CBD agreed to classify a diverse list of marine areas, some renowned for containing 'hidden treasures' of the plant and animal world, as ecologically or biologically significant.

6.3.3. UNITED NATIONS CONFERENCE ON SUSTAINABLE DEVELOPMENT- RIO+20

The future we want – The Head of government of the various states assembled at Rio de Janeiro in 2012 to mark the 20 years of the Earth Summit. They recognized that opportunities for people to influence their lives and future, participate in decision-making and voice their concerns are fundamental for sustainable development. It aimed at renewing political commitment via reaffirming the Rio Principles and past action plans; Advancing integration, implementation and coherence by assessing the progress to date and the remaining gaps in the implementation of the outcomes of the major summits on sustainable development and addressing new and

emerging challenges. The summit emphasized on *Green economy*[7] in the context of sustainable development and poverty eradication. The summit gave due consideration to International financial institutions and United Nations operational activities at regional, national, sub national and local levels. The framework for action included poverty eradication, food security and nutrition and sustainable agriculture, water and sanitation, energy, sustainable transport, sustainable cities and human settlements, human health and promoting full and productive employment, decent work for all and social protection. It also emphasized on climate change, forest protection, and conservation of biodiversity, land degradation, sustainable consumption, gender equality and women empowerment.

6.4. ECOLOGY RELATED LEGISLATIONS IN INDIA

Considering the complexity in terms of conservation of biodiversity, sustainability of the natural ecosystems and the livelihood dependence of the local communities, the government needs to address national and global issues related to carbon accumulation, biodiversity conservation, and continued flow of ecosystem services. These measures provide opportunities for strengthening documentation and data collection; empowering local communities by recognizing responsibilities, ownerships, rights, and concessions; and creating suitable institutions. The legislative provisions developed as a follow-up to such national policies are listed below:

6.4.1. INDIAN FOREST ACT, 1927

This Act recognises forest dwellers' rights and makes conservation more accountable.The Act basically does two things: (i) Grants legal recognition to the rights of traditional forest dwelling communities, partially correcting the injustice caused by the forest laws, and (ii) Makes a beginning towards giving communities and the public a voice in forest and wildlife conservation.

The law recognises three types of rights: ***Land Rights-*** Land rights are given to people, who have been cultivating land prior to December, 13, 2005.***Use Rights-*** The law provides for rights to use and/or collect the minor forest produce things like tendupatta, herbs, medicinal plants etc "that has been traditionally collected, use of grazing grounds and water bodies and use of traditional areas by nomadic or pastoralist communities i.e. communities that move with their herds, as opposed to practicing settled agriculture. ***Right to Protect and Conserve-*** Besides, the law also gives rights to protect and manage the forests to people of village communities.

The Act also categorises forests into three categories: ***Reserve forest-*** These forests are the most restricted forests and may be constituted by the State Government on any forest land or waste land which is the property of the Government or on which the Government has proprietary rights. In reserved forests, most uses by local people are prohibited, unless specifically allowed by a Forest Officer in the course of settlement. ***Protected forest-*** The State Government is empowered to constitute any land other than reserved forests as protected forests over which the Government has proprietary rights. Under 'Protected Forests', the Government retains the power to issue rules regarding the use of such forests and retains the power to reserve the specific tree species in the protected forests. This power has been used to establish State control over trees, whose timber, fruit or other non-wood products have revenue-raising potential. ***Village forest-*** 'Village forests' are the one in which the State Government may assign to 'any village community the rights of Government to or over any land which has been constituted a reserved forest'.

6.4.2. WILDLIFE PROTECTION ACT, 1972 (WITH AMENDMENT ACTS OF 2003 AND 2006)

The act provides for the protection of wild animals, birds and plants and matters connected with them, with a view to ensure the ecological and environmental security of India. The act constitutes a National Board for Wildlife that provides guidelines for framing policies and advising Central and State Government on promotion of wildlife conservation and controlling poaching and illegal trade of wildlife and its products;Making recommendations for setting up and managing national parks, sanctuaries and other protected areas; and

[7] A green economy is one whose growth in income and employment is driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. These investments need to be catalyzed and supported by targeted public expenditure, policy reforms and regulation changes. This development path should maintain, enhance and, where necessary, rebuild natural capital as a critical economic asset and source of public benefits, especially for poor people whose livelihoods and security depend strongly on nature.

Suggesting measures for improvement of wildlife conservation. It also sets up National Tiger Conservation Authority. The acts sets up various provisions related to trade and penalties for hunting the animals in wild.

Five kinds of protected areas can be notified in the Act. These are: **Sanctuaries-** The State or Central Government may by notification declare its intention to constitute any area as a sanctuary for protecting wildlife and the environment. The government determines the nature and extent of rights of persons in or over the land within the sanctuary. **National Parks:** The State or Central Government may declare an area, whether inside a sanctuary or not, as a national park for the purpose of protecting and developing wildlife and its environment. The State Government cannot alter the boundaries of a national park except on the recommendation of the National Board for Wildlife. No grazing is allowed inside a national park. All provisions applicable to a sanctuary are also applicable to a national park. **Conservation Reserves-** The State Government after consultations with local communities can declare any area owned by the Government, particularly areas adjacent to national parks or sanctuaries, as conservation reserves. The government constitutes a Conservation Reserve Management Committee to manage and conserve the conservation reserve. **Community Reserves-** The State Government can, in consultation with the community or an individual who have volunteered to conserve wildlife, declare any private or community land as community reserve. A Community Reserve Management Committee shall be constituted by State Government for conserving and managing the reserve. **Tiger Reserve-** These areas were reserved for protection tiger in the country. The State Government on the recommendation of the Tiger Conservation Authority may notify an area as a tiger reserve, for which it has to prepare a Tiger Conservation Plan.

6.4.3. THE ENVIRONMENT (PROTECTION) ACT 1986

The Environment Protection Act, 1986 was constituted on 19 Nov, 1986, to provide for the protection and improvement of environment and for matters connected with environment that lays down the standards, policies and act of environmental degradations and policies for improvement of environment and prevention of human beings from environmental hazards. It describes rules to regulate environmental pollution, laying down procedures and standards for industrial waste, emissions, hazardous waste etc. Besides, it deals with the prevention, control and abatement of environmental pollution.

6.4.4. BIOLOGICAL DIVERSITY ACT, 2002

The government passed the biodiversity act to conserve and promote sustainable use of biological diversity and to regulate the access to biological resources of the country with equitable share in benefits. It sets up National Biodiversity Authority (NBA), State Biodiversity Board (SBB) and Biodiversity Management Committees. Besides, it aims to respect and protect knowledge of local communities traditional knowledge related to biodiversity and secure sharing of benefits with local people as conservers of biological resources and holders of knowledge and information relating to the use of biological resources. Besides, it also has provisions for notifying heritage sites by State Government in consultation with local body.

6.4.5. NATIONAL GREEN TRIBUNAL ACT, 2010

The Act enables creation of a special tribunal to handle the expeditious disposal of the cases pertaining to environmental issues. The Tribunal has Original Jurisdiction on matters of “substantial question relating to environment” & “damage to environment due to specific activity.” Tribunal is competent to hear cases for several acts such as Forest (Conservation) Act, Biological Diversity Act, Environment (Protection) Act, Water & Air (Prevention & control of Pollution) Acts etc. and also have appellate jurisdiction related to above acts after establishment of Tribunal within a period of 30 days of award or order received by aggrieved party.

6.5. IMPORTANT POLICY MEASURES TOWARDS ENVIRONMENT PROTECTION AND CONSERVATION

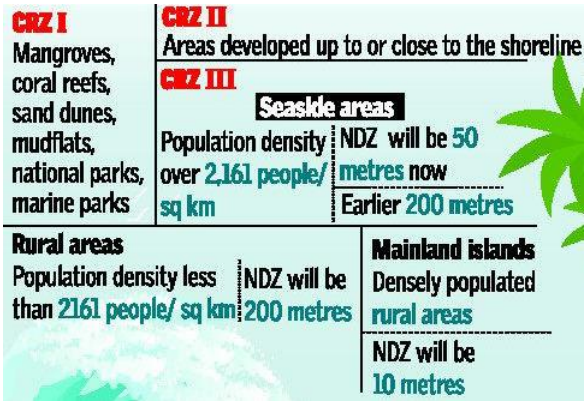
6.5.1. COASTAL REGULATION ZONE

As per the government notification, the coastal land up to 500m from the High Tide Line (HTL) and a range of 100m along banks of creeks, estuaries, backwater and rivers subject to tidal fluctuations, is called the Coastal Regulation Zone(CRZ). CRZ along the country has been placed in four categories. It includes only the inter-tidal zone and land part of the coastal area and does not include the ocean part. The notification regulates setting up

and expansion of industries or processing plants, construction activity, dumping of waste, mining etc. in the said CRZ. It does not impose any restrictions of fishing activities.

Objectives of setting up CRZ are:

- Protection of livelihoods of traditional fisher folk communities
- Preservation of coastal ecology
- Promotion of economic activity that have necessarily to be located in coastal regions.



Shailesh Nayak Committee

The Sailesh Nayak committee report was commissioned in June 2014 after states expressed dissatisfaction regarding the limitations set by the CRZ notification of 2011. The committee recommended several relaxations in the terms set by the 2011 notification. It also endorsed dilution of regulatory powers held by the central government in coastal areas. The recommendations have been put forth with the objective of giving a boost to tourism, port construction and real estate.

- On development and construction, the report recommends that all activities except those requiring environmental clearances should fall under the ambit of the state and local planning bodies instead of being regulated by central policy. The areas affected by this amendment would be coastal towns, rural areas and waters up to 12 nautical miles from the coast.
- For rural areas with a population density of over 2,161 persons/sq km, the committee has recommended that the "no-development buffer zone" be limited to 50m from the High Tide Line (HTL). For other areas, the buffer has been recommended at 200m from the HTL. This HTL, though has not been determined for the country's coastline yet and is currently being put together by the National Centre for Sustainable Coastal Management.
- It also allows reclamation of lands for specific infrastructure such as ports, bridges and fisheries-related structures for the "larger public interest". The recommendations make a case for allowing temporary tourist facilities in no-development zones in coastal areas as well as permanent structures on the landward sides of national/state highways when these pass through these zones.
- Suggested that urban planning rules prepared by local authorities be prioritised for slum development and rehabilitation instead of the 2011 regulations which were deemed restrictive by states. States would also be able to decide the Floor Area Ratio for construction activity in coastal areas if the recommendations are implemented.
- Limited the central government's role in coastal areas to environmental clearances and regulating environmentally-sensitive areas.

6.5.2. ECO-SENSITIVE ZONES (ESZS)

ESZs are areas around Protected Areas (such as National Parks and Wildlife Sanctuaries) to prevent ecological damage caused due to developmental activities. ESZs are ecologically important areas notified under the Environment Protection Act to be protected from industrial pollution and unregulated development. The purpose of declaring ESZs is to create some kind of "shock absorbers" to the protected areas by regulating and managing the activities around such areas. They also act as a transition zone from areas of high protection to areas involving lesser protection. The basic aim is to regulate certain activities around National Parks and Wildlife Sanctuaries so as to minimize the negative impacts of such activities on the fragile ecosystem encompassing the protected area.

Activities permitted in the areas include ongoing agriculture and horticulture practices by local communities, rainwater harvesting, organic farming, adoption of green technology and use of renewable energy sources.

The width of the ESZ and type of regulation may vary from protected area to area. However, as a general principle, the width of the ESZ could go up to 10 kms around the protected area.

6.5.3. WETLAND RULES

Under the Rules notified in 2010, wetlands have been classified for better management and easier identification. Central Wetland Regulatory Authority has been set up to ensure proper implementation of the Rules and perform all functions for management of wetlands in India. Apart from necessary government representatives, the Authority shall have a number of expert members to ensure that wetland conservation is carried out in the best possible manner. In order to ensure there is no further degradation of wetlands, the Rules specify activities which are harmful to wetlands such as industrialisation, construction, dumping of untreated waste, reclamation etc. and prohibit these activities in the wetlands. Other activities such as harvesting, dredging etc may be carried out in the wetlands but only with prior permission from the concerned authorities.

6.5.4. HAZARDOUS WASTE MANAGEMENT RULES

It ensures safe handling, generation, processing, treatment, package, storage, transportation, use reprocessing, collection, conversion, and offering for sale, destruction and disposal of Hazardous Waste. These Rules came into effect in the year 1989. The Rules lay down corresponding duties of various authorities such as MoEF, CPCB, State/UT Govts., SPCBs/PCCs, DGFT, Port Authority and Custom Authority while State Pollution Control Boards/ Pollution Control Committees have been designated with wider responsibilities touching across almost every aspect of Hazardous wastes generation, handing and their disposal.

6.5.5. OZONE DEPLETING SUBSTANCE RULES

Notified in year 2000 under the Environment (Protection) Act. It sets the deadlines for phasing out such substances along with regulation of their production, trade, import and export.

6.6. NATIONAL WILDLIFE CONSERVATION PROJECTS

Last few decades have seen emergence of human encroachment to an extent that has never been seen before. This is one of the greatest threats to India's wildlife. In order to overcome the result of human encroachment many national parks as well as protected areas have been established so far and the first came in 1935. Also in 1972, to protect the tiger and wildlife in India, the Wildlife Protection Act and Project Tiger to safeguard were enacted. The following are the major conservation projects ongoing in India:

6.6.1. PROJECT TIGER

Project Tiger is a wildlife conservation project initiated in India to protect the Bengal Tigers. It was launched on April 1, 1973. The project aims at tiger conservation in specially constituted tiger reserves representative of various bio-geographical regions throughout India. The project was based on a 'core-buffer' strategy. The core areas were freed from all sorts of human activities and the buffer areas were subjected to 'conservation oriented land use'. Management plans were drawn up for each tiger reserve based on the principles of elimination of all forms of human exploitation and biotic disturbance from the core area and rationalization of activities in the buffer zone; restricting the habitat management only to repair the damages done to the eco-system by human and other interferences so as to facilitate recovery of the eco-system to its natural state; and monitoring the faunal and floral changes over time and carrying out research about wildlife.

Starting from nine reserves in 1973-74 the number has grown up to forty one. As per 2010 census, India was home to 1,706 tigers which was half the world's tiger population. A new census started in the 2013-2014 which will use three tests for counting tiger including camera trap and DNA testing of tiger scat to minimise duplicate counting. Every tiger caught on camera will be given a unique identification number based on their stripe patterns using computer software and a database maintained for the entire country.

6.6.2. PROJECT ELEPHANT

Project Elephant (PE), a centrally sponsored scheme, was launched in February 1992 to provide financial and technical support to major elephant bearing states in the country for protection of elephants, their habitats and corridors. It also seeks to address the issues of human-elephant conflict and welfare of domesticated elephants.

Main activities of the Project are as follows: Ecological restoration of existing natural habitats and migratory routes of elephants; Development of scientific and planned management for conservation of elephant habitats

and viable population of Wild Asiatic elephants in India; Promotion of measures for mitigation of man elephant conflict in crucial habitats and moderating pressures of human and domestic stock activities in crucial elephant habitats; Strengthening of measures for protection of Wild elephants form poachers and unnatural causes of death; Eco-development and Veterinary care.

6.6.3. PROJECT SNOW LEOPARD

Project Snow Leopard is a step of the Government of India's resolve to conserve biodiversity with community participation.Snow Leopard is globally endangered species as well as the most important flagship species of the mountain region. The project will be operational in five Himalayan States viz. Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh with active support from wildlife institute of India and the Mysore based Nature Conservation Foundation. The project stresses on a landscape approach to conservation wherein smaller core zones with relatively conservation values will be identified and conserved with support and the larger landscape will be managed in such a way that it allows necessary development benefits to the local communities. The project thus places greater importance to careful and knowledge-based management planning of the landscapes. Species such as Snow Leopard, Asiatic Ibex, Tibetan Argali, LadakhUrial, Chiru, Takin, Serow and Musk Deer will particularly benefit from this project.

6.6.4. INDIAN CROCODILE CONSERVATION PROJECT

The Indian Crocodile Conservation Project is one of the most successful conservation initiatives in the world. It has pulled back the once threatened crocodilians from the brink of extinction and placed them on a good path of recovery. The Project has not just produced a large number of crocodiles, but has contributed towards conservation in a number of related fields as well. The broad objectives of activities under crocodile project were to protect the remaining population of crocodilians in their natural habitat by creating sanctuaries; to rebuild natural population quickly through `grow and release' or `rear and release' technique - more than seven thousand crocodiles have been restocked- about 4000 gharial (*Gavialisgangeticus*), 1800 mugger (*Crocodyluspalustris*) and 1500 salt- water crocodiles (*Crocodylusporosus*); to promote captive breeding; to take-up research to improve management; and to involve the local people in the project intimately.

6.6.5. ACTION PLAN FOR VULTURE CONSERVATION IN INDIA

India has nine species of vultures in the wild. These are the Oriental White-backed Vulture (*Gypsbengalensis*), Slender billed Vulture (*Gyps tenuirostris*), Long billed Vulture (*Gyps indicus*), Egyptian Vulture (*Neophronpercnopterus*), Red Headed Vulture (*Sarcogypscalvus*), Indian Griffon Vulture (*Gyps fulvus*), Himalayan Griffon (*Gyps himalayensis*), Cinereous Vulture (*Aegypiusmonachus*) and Bearded Vulture or Lammergeier (*Gypaetusbarbatus*). The population of three species i.e. White-backed Vulture, Slender billed Vulture and Long billed Vulture in the wild has declined drastically over the past decade. The decline of Gypsgenus in India has been put at 97% by 2005. Because of the evidence of widespread and rapid population decline, all three vulture species were listed by IUCN, the World Conservation Union, in 2000 as 'Critically Endangered'.

Experiments showed that captive vultures are highly susceptible to Diclofenac, and are killed by kidney failure leading to gout within a short time of feeding on the carcass of an animal treated with the normal veterinary dose. There have been major initiatives for complete ban on the use of Diclofenac and finding a suitable substitute for the same. The Supreme Court has also given instructions for phasing out of Diclofenac.

6.6.6. INDIAN RHINO VISION 2020

The greater one-horned rhinoceros (*Rhinoceros unicornis*) is listed as Vulnerable on the IUCN Red List of Threatened Species. Wild populations of the species, currently number approximately 3,270 individuals, are found in northern India and Nepal. Close to 85% of the total population occurs in India, with about 75% in the state of Assam. Indian Rhino Vision (IRV) 2020 is a partnership the Assam Forest Department, the Bodoland Territorial Council, the World Wide Fund for Nature (WWF), the International Rhino Foundation (IRF), and the US Fish and Wildlife Service. The goal is to attain a wild population of at least 3,000 greater one-horned rhinos in the Indian state of Assam - spread over seven protected areas - by the year 2020.

6.7. NATIONAL ACTION PLAN ON CLIMATE CHANGE

The Government of India released in 2008 India's first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate mitigation and adaptation. The plan identifies eight core "national missions" running through 2017. Emphasizing the overriding priority of maintaining high economic growth rates to raise living standards, the plan "identifies measures that promote our development objectives while also yielding co-benefits for addressing climate change effectively."

6.7.1. NATIONAL MISSIONS

1. National Solar Mission: The NAPCC aims to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar competitive with fossil-based energy options. The plan includes:

- Specific goals for increasing use of solar thermal technologies in urban areas, industry, and commercial establishments;
- A goal of increasing production of photovoltaic to 1000 MW/year; and
- A goal of deploying at least 1000 MW of solar thermal power generation.

Other objectives include the establishment of a solar research centre, increased international collaboration on technology development, strengthening of domestic manufacturing capacity, and increased government funding and international support.

2. National Mission for Enhanced Energy Efficiency: Initiatives based on increasing the energy use efficiency were expected to yield savings of 10,000 MW by 2012. Building on the Energy Conservation Act 2001, the plan recommends:

- Mandating specific energy consumption decreases in large energy-consuming industries, with a system for companies to trade energy-savings certificates;
- Energy incentives, including reduced taxes on energy-efficient appliances; and
- Financing for public-private partnerships to reduce energy consumption through demand-side management programs in the municipal, buildings and agricultural sectors.

3. National Mission on Sustainable Habitat: To promote energy efficiency as a core component of urban planning, the plan calls for:

- Extending the existing Energy Conservation Building Code;
- A greater emphasis on urban waste management and recycling, including power production from waste;
- Strengthening the enforcement of automotive fuel economy standards and using pricing measures to encourage the purchase of efficient vehicles; and
- Incentives for the use of public transportation.

4. National Water Mission: With water scarcity projected to worsen as a result of climate change, the plan sets a goal of a 20% improvement in water use efficiency through pricing and other measures.

5. National Mission for Sustaining the Himalayan Ecosystem: The plan aims to conserve biodiversity, forest cover, and other ecological values in the Himalayan region, where glaciers that are a major source of India's water supply are projected to recede as a result of global warming.

6. National Mission for a "Green India": Goals include the afforestation of 6 million hectares of degraded forest lands and expanding forest cover from 23% to 33% of India's territory.

7. National Mission for Sustainable Agriculture: The plan aims to support climate adaptation in agriculture through the development of climate-resilient crops, expansion of weather insurance mechanisms, and agricultural practices.

8. National Mission on Strategic Knowledge for Climate Change: To gain a better understanding of climate science, impacts and challenges, the plan envisions a new Climate Science Research Fund, improved climate modelling, and increased international collaboration. It also encourages private sector initiatives to develop adaptation and mitigation technologies through venture capital funds.

Government is contemplating adding four new missions to NAPCC:

Wind energy

- Modelled on National Solar Mission
- To be serviced by Ministry of New and Renewable Energy
- To produce 50,000-60,000 MW of power by 2022

Human health

- Assess impact of climate change on human health
- Build up capacities to respond to these
- Being looked after by Health Ministry

Coastal resources

- Prepare integrated coastal resource management plan
- Map vulnerabilities along the entire shoreline
- Environment Ministry to look after the mission

Waste-to-energy

- Incentivise efforts towards harnessing energy from waste
- Lower dependence on coal, oil, gas
- Make power production a more earth-friendly process

POST 2015 DEVELOPMENT FRAMEWORK-SUSTAINABLE DEVELOPMENT GOALS

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7. POST 2015 DEVELOPMENT FRAMEWORK- SUSTAINABLE DEVELOPMENT GOALS

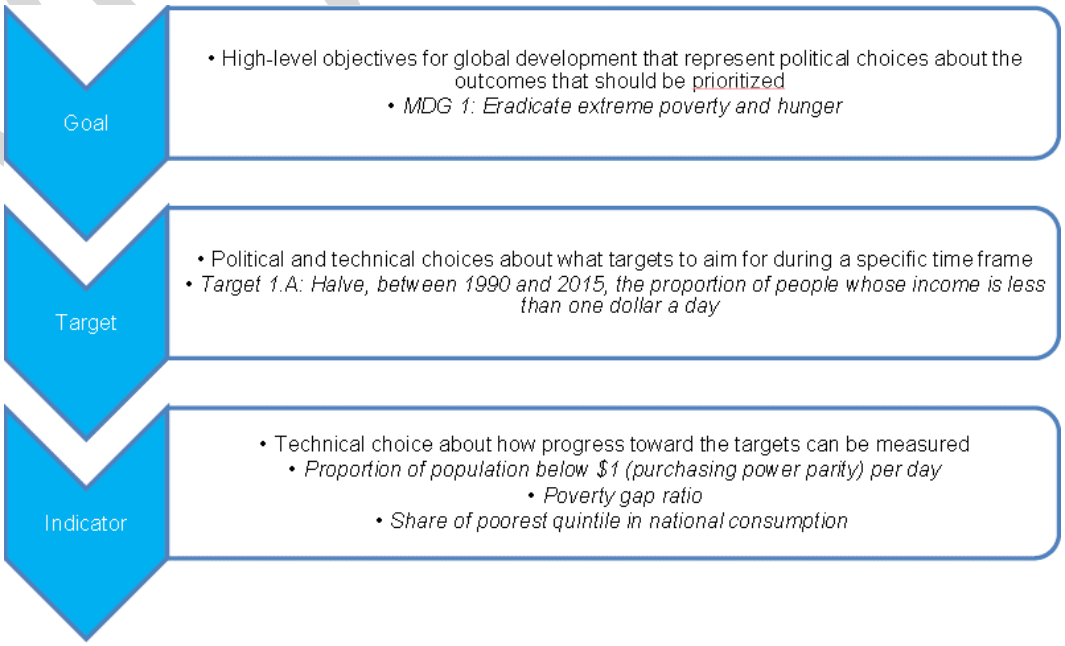
The meaning of development and the processes and methods adopted to bring it about have kept on evolving over the years. Realization of the human rights based social aspect of development led to the emergence of concepts like inclusive development and good governance, which were sought to be implemented through frameworks like MDGs. Similarly, the concept of sustainable development brought together economic development and environment. In the Brundtland report, the concept of sustainable development is defined as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

7.1. MILLENNIUM DEVELOPMENT GOALS: MDGS

At the Millennium Summit in September 2000 the largest gathering of world leaders in history adopted the UN Millennium Declaration, committing their nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound and quantified targets, with a deadline of 2015, that have become known as the Millennium Development Goals. They are aimed at addressing extreme poverty in its many dimensions-income poverty, hunger, disease, lack of adequate shelter, and exclusion-while promoting gender equality, education, and environmental sustainability. They are also basic human rights.

The internationally agreed framework of **8 goals** and 18 targets was complemented by 48 technical indicators to measure progress towards the Millennium Development Goals. **The goals were adopted in 2000 but base level for setting targets is 1990.**

Difference between goal, target and indicators



The Millennium Development Goals (MDGs) have been the most successful global anti-poverty push in the history. They were embraced by all UN Member States and millions of peoples' lives have improved due to concerted, targeted efforts by many countries, groups and individuals.

7.1.1. EVALUATION OF THE SUCCESS OF MDGS

While some targets are unlikely to be met without accelerated progress, others – such as reducing extreme poverty – were met comfortably ahead of schedule. Also targets like gender equality in terms of gender parity index, reversing the trend of HIV and Aids cases and halving the proportion of people without access to safe drinking water have been achieved. In contrast to these we are far behind with respect to targets related to child mortality, maternal mortality, sanitation, hunger and education.

Target	Then	Now
Poverty: halve the proportion of people living in extreme poverty	1990 **46.7%**	2010 **22%**
Hunger: halve the proportion of hungry people	1990 **18.6%**	2010-12 **12.5%**
Education: ensure all children can complete primary school	1990 **81.9%**	2011 **91.2%**
Gender equality: end gender disparities in schools*	1990 **0.88**	2011 **0.97**
Child mortality: cut under-5 mortality rate (per 1,000 live births) by two thirds	1990 **87**	2012 **50**
Maternal mortality: cut maternal mortality rate (per 100,000 live births) by three quarters	1990 **400**	2010 **210**
HIV and Aids: halt and begin to reverse the spread of HIV and Aids **	2001 **0.08**	2011 **0.06**
Water: halve the proportion of people without access to safe drinking water	1990 **24%**	2011 **11%**
Sanitation: halve the proportion of people without access to basic sanitation	1990 **51%**	2011 **36%**

* Gender parity index (ratio of girls to boys)
** Incidence of new cases (per 100 people)

7.1.2. ACHIEVEMENTS OF MDGS

- Simple, measurable and time bound to support accountability.
- MDGs have focused minds on broader measures of **human development**, as opposed to economic growth alone.
    - **Reduction of poverty:** The main goal – to halve the number of people living on less than $1.25 a day – was achieved before the 2015 deadline despite the absence of any legally binding enforcement mechanism. The number of people in extreme poverty declined by an estimated 130 million. Rapid economic development in countries such as China, though, was a major factor leading some to say that poverty would have been halved regardless of the MDGs. But along with this, the MDGs provided a set of clear international priorities that helped channel substantial funding from aid agencies and foundations.
    - Between 1990 and 2002 average overall incomes increased by approximately 21 percent.
    - Child mortality rates fell from 103 deaths per 1,000 live births a year to 88.
    - Life expectancy rose from 63 years to nearly 65 years.
    - An additional 8 percent of the developing world's people received access to water and an additional 15 percent acquired access to improved sanitation services.
- Over the past decade, the MDGs have become a **central reference point for aid and international cooperation**, not only providing a compelling vision for international development, but also a set of quantitative benchmarks against which development progress can be measured.
- Helped in generating popular **awareness** for ending poverty, and supporting increases in aid.
- The MDG process has **helped improve the capacities of national statistics offices** through its focus on specific, measurable targets.

7.1.3. CRITICISMS OF MDGS: HICCUPS TO BE AVOIDED BY ANY POST-2015 DEVELOPMENT MODEL

- **Top-down and straight jacket approach:** They are charged with neglecting issues in developed countries, not considering the real needs in recipient countries, particularly those of marginalised populations. One of the causes of this is, its utilisation of a donor- driven design. Failed to tackle the root causes of poverty and underdevelopment. Post-2015 framework for development must be bottom-up supported by inclusive and transparent process. It should adopt global goals that reflect global priorities but targets that can be tailored to national and sub-national contexts.

- **No goals or commitments** for developed countries and **no compulsion** for members to follow the MDGs. No indication of what happens if goals are unmet at the end of the target period.
- **Incomplete agenda:** The MDGs have also been criticised for the dimensions they have omitted. Critics argue, for example, that the goals do not place enough emphasis on sustainable development, and leave out crucial issues such as 'peace, security and disarmament' as well as 'Human rights, democracy and good governance'. Moreover, they cover only some dimensions of multidimensional poverty.
- **Improper target setting:** Some goals at the global level were unrealistic right from the start (e.g. MDG 2, which demands total enrolment in primary education worldwide), while others demonstrate low ambitions, at least at the global level (e.g. MDG1, which asks for halving the share of people that suffer from income poverty and which according to the World Bank has already been achieved). Some MDGs cannot even be measured – either because no indicators or targets were set, or because for certain indicators no data is available.
- **Financial issues:** Financial Support Targets and indicators for Overseas Development Assistance (ODA) were not backed up by any quantitative or time-bound targets. Levels of international aid have been minimal and have not been able to play any significant role in fostering achievement of MDGs and targets. Overall ODA required for supporting the MDGs estimated to be US$ 195 billion in 2015 (equivalent to 0.44 and 0.54 percent of the combined GNP of donor nations); in 2012, the net ODA from developed countries was USS 125.6 billion, a meagre 0.29 percent of donors' combined gross national income (UNDP. 2013). Also, there has been inappropriate administration of funds in some cases.
- **Non-uniform achievement of targets**: There are huge disparities across and within countries. Sub-Saharan Africa is the epicentre of crisis and a widespread shortfall for most of the MDGs. Asia is the region with the fastest progress, but even there hundreds of millions of people remain in extreme poverty. Within countries, poverty is greatest for rural areas, though urban poverty is also extensive, growing, and underreported by traditional indicators.
- **Focus on output rather than outcome:** Some MDGs measure outputs or inputs rather than outcomes or impacts of development. MDG2, for example measures only the intake of education, regardless of its quality or relevance for economic, social and political life.
- **MDGs neglect distributive issues:** For instance, when a particular country lowers its child mortality rate, then MDG 4 does not capture whether this is due to improvements in the health of the most disadvantaged or others that are better off in terms of child survival. For policy makers it may be cheaper and hence more attractive to invest in the health of the latter rather than those at the bottom of the pyramid.
- **Little progress with MDG8**: Fair open trading system, dealing with the debt problem, providing access to medication in developing countries, and making available the benefits of new technologies, including ICTs
- **The MDGs cannot easily be transformed into national objectives:** They were originally formulated as global goals, but they were increasingly seen as national objectives in order to create national accountability.

Figure 4. Lessons for the Post-2015 development framework

7.1.4. INDIA AND MDGS

Economic survey 2013 suggests that India is on track to achieve targets like poverty reduction, household with water access, gender parity, universal primary education and under five mortality rate. But there are targets related to maternal mortality rate, share of women in non-agriculture employment, birth attended by skilled personnel and sanitation, which are unlikely to be achieved by India by next year.

Box 12.1 : MDGs and Targets : Summary of Progress Achieved by India

Indicators		MDG Target 2015	Likely Achievement 2015
MDG 1: Eradicate Extreme Poverty and Hunger			
Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day			
Proportion of population below poverty line (per cent)		23.9	20.74
MDG 2: Achieve Universal Education			
Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling			
Net enrolment ratio in primary grade (per cent)		100	100
Literacy rate (15-24 years)		100	100
MDG 3: Promote Gender Equality and Empower Women			
Target 4 : Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015			
Gender parity index (Ratio of boys to girls in primary education)		1	1
Share of women in wage employment in the non-agricultural sector (per cent)		50	23.1
MDG 4: Reduce Child Mortality			
Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five morality rate			
Under five mortality rate (per 1000 live births)		42	50
Infant mortality rate (per 1000 live births)		27	41
MDG 5: Improve Maternal Health			
Target 6: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio			
Maternal mortality ratio (per 100,000 live births)		109	139
Proportion of births attended by skilled personnel (per cent)		100	62
MDG 7: Ensure Environment Sustainability			
Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation			
Households with sustainable access to an improved water source (per cent)	Urban	93.56	97.5
	Rural	79.47	96.3
Households without access to sanitation (per cent)	Urban	15.84	12.14
	Rural	46.64	61.11

7.2. POST-2015 DEVELOPMENT FRAMEWORK

The wheels for establishing the post-2015 framework are in motion. Two United Nations (UN) processes are running in parallel:

- **Post-2015 development agenda**, by the High-Level Panel of Eminent Persons. It is a process led by the UN Secretary-General, responding to a mandate from the General Assembly in 2010 following an event to accelerate progress towards achieving the Millennium Development Goals (MDGs). On the 30th May 2013 the HLP published its report. The report outlines new priorities, global goals and affiliated targets for development while also drawing on experience gained from implementing the MDGs. However it is important to note that these have not been agreed upon by governments at the UN level. The HLP Report is one of several reports the UN Secretary-General will draw upon to create his own report on post-2015.
- **Sustainable Development Goals (SDGs)**, which were agreed on in principle at Rio+20 and developed by an intergovernmental Open Working Group (OWG) on the SDGs of the UN General Assembly.

Stakeholders have consistently expressed their desires that the post- 2015 development agenda and the SDGs processes converge to establish just one set of global development goals. One of the main outcomes of the Rio+20 Conference in 2012 was the agreement by member States to launch a process to develop a set of Sustainable Development Goals (SDGs), which will build upon the Millennium Development Goals and converge

with the post-2015 development agenda. It was decided to establish an "inclusive and transparent intergovernmental process open to all stakeholders, with a view to developing global sustainable development goals to be agreed by the General Assembly".

Following figure shows the relationship among the above three and makes it clear that SDGs are different that MDGs beyond 2015 and Post-2015 Agenda is now a broad development framework which includes SDGs.

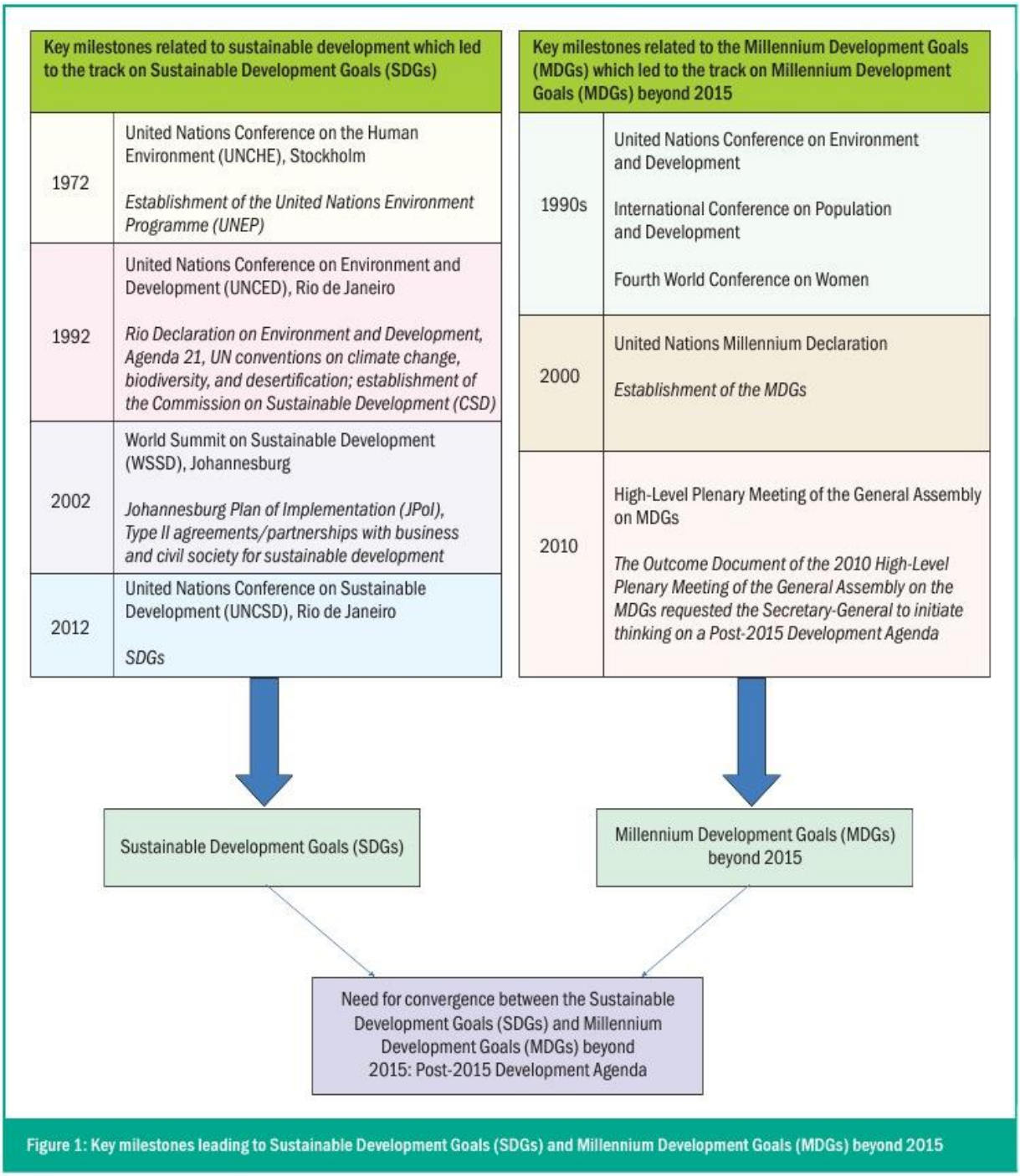


Figure 1: Key milestones leading to Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs) beyond 2015

It should be clarified that SDGs are not an alternative to the past or ongoing frameworks, including MDGs, but can address the shortcomings and challenges facing MDGs, and broaden their goals to reflect other SD objectives, as already agreed to by governments.

7.2.1. FACTORS TO BE KEPT IN MIND WHILE WEAVING THE POST-2015 DEVELOPMENT FRAMEWORK

- **Inclusive and sustainable development:** The centre issues in international development have changed. While the MDGs reflect a focus on extreme poverty and social development, a broad consensus has emerged that the international development community must do a better job of integrating environmental sustainability into its architecture and actions.

- **Changing global context:** The MDGs were conceived in an era of relative stability and strong growth, when global power was more concentrated and the development lexicon was largely focused on more and better aid from rich countries and better policies in poor ones. The geopolitical map is more complicated and fragmented today than it was in 2000. The Group of Eight is no longer the core economic grouping on issues of global importance, since emerging economies and the Group of Twenty have made global governance more diffuse.
- **Stakeholders outside government**, such as the private sector, philanthropic foundations, and citizens' movements, are more woven into global affairs. Foundations, such as the Bill & Melinda Gates Foundation, and philanthropists are playing more prominent roles in global development today.
- **Diversification of finance sources for development**: While aid remains a critical resource for many low- and middle-income countries, other sources of finance for development, including taxation, remittances, and investment, are of greater importance now than in 2000.

Box 1. Trends in financing for development

Expanded domestic tax revenues: Developing countries have been expanding their domestic tax revenues, giving more scope for development to be funded domestically.

Increased foreign direct investment, remittance, and philanthropic flows: Foreign direct investment and remittances tripled in nominal terms between 2001 and 2010, while philanthropic funding more than tripled between 2003 and 2009.

Decline in the relative importance of ODA: The relative importance of ODA has declined compared to other forms of finance. In middle-income countries, ODA/gross domestic product ratios nearly halved in the 2000s. These trends are uneven across countries, however, with private cross-border flows concentrated in middle-income countries, and low-income countries remaining dependent on aid to finance development.

Growth in "aid-like" development finance: While traditional ODA is under pressure, there has been rapid growth in forms of development finance that are "aid-like"—they are not classified as ODA but have a public-interest purpose (for example, South-South cooperation, philanthropy, and climate finance). Flows of "aid-like" development finance have been growing significantly over the past decade.

- **Changing nature of problems:** Today many of the challenges that the world faces, including climate change, financial regulation, tax avoidance, and insecurity, require global solutions. But this is at a time when confidence in the multilateral system is waning.
- **System approach to policy formulation:** While the 1990s in the West marked the high point of "planner" mentality in public policy, today there is increased attention paid to systems thinking, complexity, and change, with development portrayed "as an emergent, inherently unpredictable and discontinuous process".

Figure 5. Shifts required for "fit-for-purpose" development policy

From		To
Development assistance		A universal global compact
Top-down decision making		Multi-stakeholder decision making
Growth models that increase inequality and risks		Growth models that decrease inequality and risks
Meeting "easy" development targets		Tackling systemic barriers to progress
Concepts and testing		Scaled-up interventions
Multiple discrete actions		Cross-scale coordination

7.3. UN CONFERENCE ON SUSTAINABLE DEVELOPMENT: RIO+20, 2012

The concept of Sustainable Development Goals (SDGs) was born at the United Nations Conference on Sustainable Development, Rio+20, in 2012. The objective was to produce a set of universally applicable goals that balances the three dimensions of sustainable development: the environmental, social, and economic.

Rio+20 committed UN Member States to develop a set of sustainable development goals (and targets and indicators) that would be balanced, coherent and comprehensive. The task of preparing a proposal on the SDGs and developing a set of measurable targets and indicators was assigned to the intergovernmental Open Working Group (OWG) of the UN General Assembly.

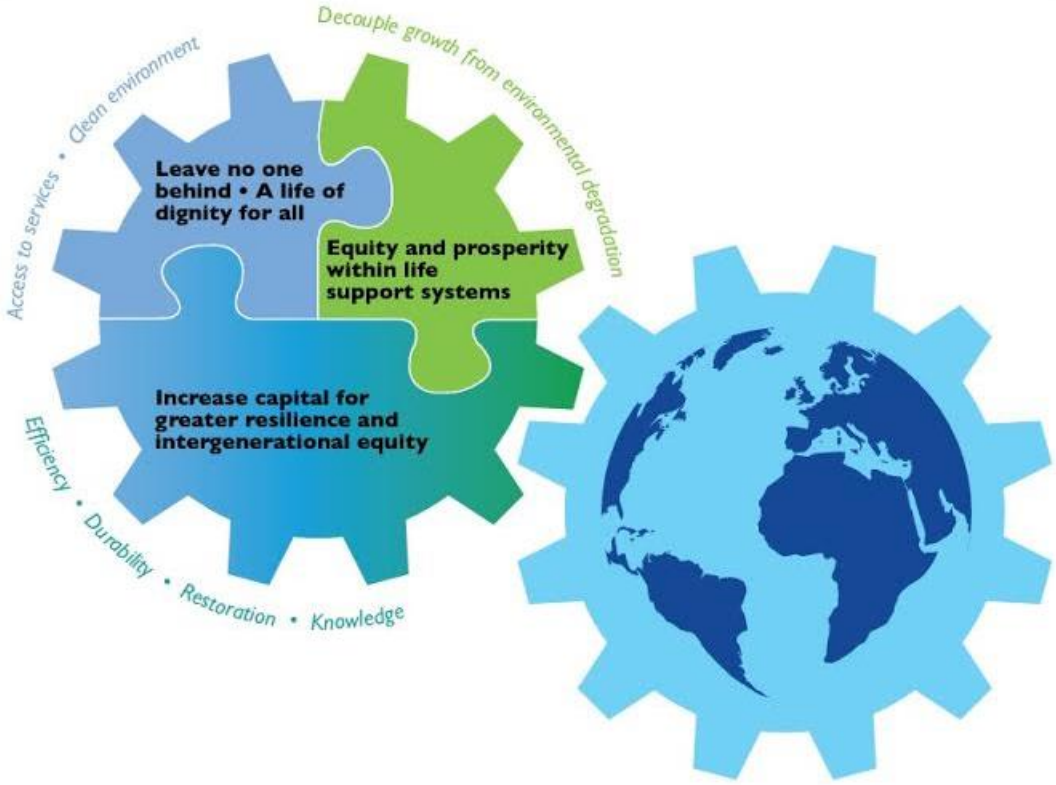
The Post-2015 Development Agenda will build on the progress achieved through the MDGs. At the same time, it will address persistent issues and new challenges facing people and the planet. The MDGs faced criticism for not sufficiently covering the environmental dimension of sustainable development, and for not addressing inter-linkages between its three dimensions.

Three basic inter-linkages underpin this cohesiveness and can be used as a "filter" to assess the completeness and robustness of the future goals, targets and indicators:

1. Leave no one behind and provide a life of dignity for all
2. Achieve greater prosperity in an inclusive manner within the capacity of the earth's life support system
3. Increase capital to achieve greater resilience and secure future generations' livelihoods

There are three other important considerations for formulating SDGs, targets and indicators:

4. They should build upon existing internationally agreed goals and targets, as agreed to in Rio+20.
5. Targets should be Solutions-oriented and actionable.
6. The targets and indicators should be scientifically credible, verifiable, measurable, and based on best available information and evidence.



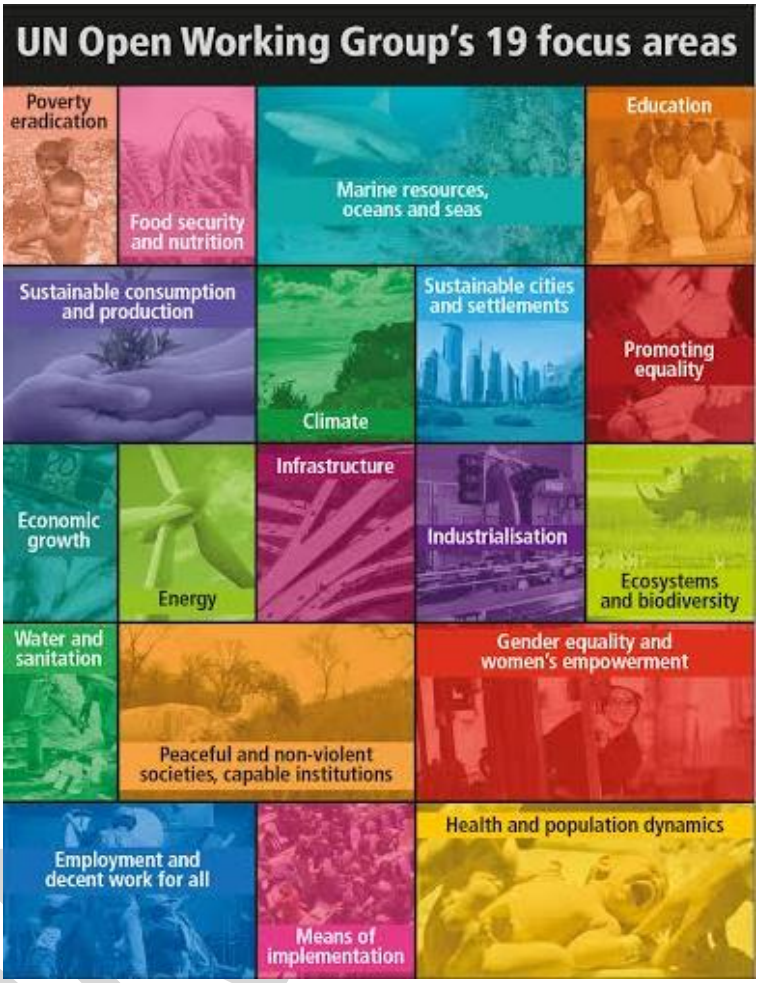
In the Rio+20 outcome document, member States agreed that sustainable development goals (SDGs) must:

1. Be based on Agenda 21 and the Johannesburg Plan of Implementation.
2. Fully respect all the Rio Principles.
3. Be consistent with international law.
4. Build upon commitments already made.
5. Contribute to the full implementation of the outcomes of all major summits in the economic, social and environmental fields.
6. Focus on priority areas for the achievement of sustainable development, being guided by the outcome document.
7. Address and incorporate in a balanced way all three dimensions of sustainable development and their inter-linkages.
8. Be coherent with and integrated into the United Nations development agenda beyond 2015.
9. Not divert focus or effort from the achievement of the Millennium Development Goals.
10. Include active involvement of all relevant stakeholders, as appropriate, in the process.

7.4. SUSTAINABLE DEVELOPMENT GOALS

The UN Open Working Group, responsible for crafting the sustainable development goals (SDGs) has released Sustainable Development Goals in July, 2014 at its 13th and final session. The UN general assembly (UNGA) adopted these goals in 2015.

There are 17 goals and 169 targets to be achieved by 2030. The list includes a reworking of the eight millennium development goals, such as eradicating poverty and hunger, improving education, and achieving gender equality, as well as new goals on water and sanitation, affordable energy, safer cities and climate change related to sustainable development.



While formulating SDGs, UN Open working Group (OWG) had following 19 focus areas

Goal 1: End poverty in all its forms everywhere

Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

Goal 3: Ensure healthy lives and promote well-being for all at all ages

Goal 4: Ensure inclusive and equitable quality education and promote life-long learning opportunities for all

Goal 5: Achieve gender equality and empower all women and girls

Goal 6: Ensure availability and sustainable management of water and sanitation for all

Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 10: Reduce inequality within and among countries

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12: Ensure sustainable consumption and production patterns

Goal 13: Take urgent action to combat climate change and its impacts

Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development: finance, technology, capacity building, trade, policy and institutional coherence, data monitoring and accounting etc.

7.4.1. CRITICAL APPRECIATION OF THE SDGS

Difference in principle behind SDGs and MDGs: How SDGs are better than MDGs:

- The SDGs will be **relevant for all countries and will measure a much broader set of factors** than the Millennium Development Goals (MDGs). This shift recognises:
  - the interconnectedness of our economies and societies
  - our dependence on a stable and productive environment and
  - the importance of greater co-operation and common frameworks for action.

- **Wider range of goals that matter from a sustainability perspective:** The MDGs are not a purely socio-political agenda and neither SDGs are just environmental. Both approaches involve similar ideas. They differ mostly with respect to their underlying thinking: While the MDGs are mostly inspired by improving the living conditions of the poorest people, the SDGs main concern is shaping development sustainably.
- It consists of a **number of manageable goals** that are easy to understand, measurable and with a deadline. On the other hand they are (i) more comprehensive than the MDGs have been, (ii) correlation sensitive, (iii) outcome-oriented, (iv) specified by indicators, (v) country specific and (vi) realistic while still ambitious.

CRITICISM of SDGs

- Proposals for a new set of UN development goals have been criticised by the Copenhagen Consensus Center, a think-tank founded by the Danish environmentalist Bjorn Lomborg. They have rated SDGs targets as Phenomenal, Poor and categories in between them. According to them **many targets are either excessively vague or are having bad cost-benefit ratio**. **Only 13 out of 169 targets are phenomenal and 9 of them are totally poor. Other targets are in between these two categories.**

  The first proposed goal, to "end poverty in all its forms everywhere" was unrealistically ambitious. Some goals, such as having universal social protection systems, fighting substance abuse or offering equal access to vocational or university education, would be very expensive relative to the benefits they offered. Others, such as "ensuring all learners acquire knowledge and skills needed to promote sustainable development" were difficult to define precisely and hence unlikely to be effective. Some, such as that for sustainable tourism, focus attention on a specific area that the economists said would be better handled by a more general economy-wide objective.

- There are **few urgent issues which are not adequately addressed:** On such issue is related to Indigenous people. Indigenous people make up 5% of the world's population, and form 10% (according to the World Bank) to 30% (says the UN) of the world's poorest people. By most accounts, they have been the group least well served by the MDGs. In the draft of the SDGs also, they get only two mentions: in goals on hunger and education. This failure of attention to them can be attributed to their minimal say in politics across the world.

7.4.2. EFFECTIVE IMPLEMENTATION OF SDGS: 'MEANS OF IMPLEMENTATION'

The notion of 'Means of implementation' describes the interdependent mix of financial resources, technology development and transfer, capacity-building, inclusive and equitable globalization and trade, regional integration, as well as the creation of a national enabling environment required to implement the new sustainable development agenda, particularly in developing countries.

The implementation of the post-2015 development agenda will require States and other relevant actors, acting individually and collectively, to adopt policies and mobilize resources to advance equitable, human rights-based, sustainable development. In this regard, a renewed and strengthened global partnership for mobilizing the means of implementation needs to (i) address the social, economic and environmental dimensions in an integrated manner; (ii) build on existing commitments and governance structures, ensuring that new initiatives reinforce previous successes; (iii) reinforce coherence in the implementation of a universal post-2015 agenda, leveraging resources across diverse funding mechanisms; and (iv) strengthen governance and accountability frameworks, providing for multi-stakeholder engagement, including for financing, technology innovation and diffusion, and capacity building for people and institutions.

Capacity building is a cross-cutting issue in all sustainable development policy documents, including Agenda 21 and the Rio+20 outcome document.

Sustainable Development Budgets: Governments have the primary responsibility to implement the Post-2015 Agenda. This has implications for fiscal policies and the allocation of public resources. Governments will have to formulate Sustainable Development Budgets in order to implement Sustainable Development Goals.

Civil society, the private sector, the media and other relevant stakeholders should play a significant role in the delivery and the monitoring of the global partnership.

Enhanced data availability, disaggregated by criteria such as age and sex, which requires investment in data collection and management systems and transparency, should also allow the media, civil society and citizens to monitor the progress at the national, regional and global level.

Global overview: The UN, through the annual reports of the Secretary-General, could continue to provide a global overview on sustainable development and the implementation of the post-2015 development agenda. The Secretary-General's High-level Panel has recommended that "an international conference should discuss how to integrate development, sustainable development and environmental financing streams."

At a sub-global level, it would be desirable that periodic meetings of regional bodies dedicate sessions to sustainable development implementation through mutual and voluntary accountability reviews, as was suggested by the High Level Panel report on the post-2015 development agenda.

Digital divide is one of the biggest obstacles to sustainable development. To reduce this, common access to information is essential. Available data are made open and shared locally and across borders. The development of policies that will promote open access to scientific data, especially legal issues that hinder access to scientific data are needed, along with the need for research funded by governments to be made accessible to the public.

Technology transfer: Foreign direct investment contributes toward financing sustained economic growth over the long term. It is especially important for its potential to transfer knowledge and technology. A central challenge, therefore, is to create the necessary domestic and international conditions to facilitate direct investment flows. Trade is an additional important means for diffusing new technologies and knowhow. The share of GDP devoted to Research and Development (R&D) in developing countries has increased. South-South Cooperation (supplementing North-South Cooperation) has become an important catalyst for absorption of technologies tailored to developing countries' needs.

Further policy makers need to find the right balance between intellectual property rights and technology transfer to ensure both accessibility and reward (for creativity and innovation) which remains a fundamental challenge in building inclusive and sustainable development paths.

India and Sustainable Development Goals (SDGs)

India's 12th Five-Year Plan is titled *Faster, More Inclusive, and Sustainable Growth* and envisions simultaneous achievement of social, economic, and environmental goals as crucial for the success of the Plan. The Plan, thus, calls for more attention to be given to the issue of sustainability. As far as environment is concerned, India's stand is that SDGs need to include common but differentiated responsibilities.

NATURAL HAZARDS, DISASTERS AND THEIR MANAGEMENT

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8. NATURAL HAZARDS, DISASTERS AND THEIR MANAGEMENT

The "cradle of civilisation" in the Middle East eventually became a desert due to the neglect of natural assets and environment.

8.1. NATURAL HAZARDS

Change is the law of nature. It is a continuous process that goes on uninterruptedly involving phenomena, big and small, material and nonmaterial that make our physical and socio-cultural environment. Change can be a gradual or slow process like the evolution of landforms and organisms. Changes have different meanings for different people. It depends upon the perspective one takes while trying to understand them. From the perspective of nature, changes are value-neutral. But from the human perspective, these are value-loaded.

There are some changes that are desirable and good like the change of seasons, ripening of fruits, while there are others like earthquakes, floods and wars that are considered bad and undesirable. Changes which are considered bad and have haunted humankind for a long time are our point of discussion here.

What is a **natural hazard**? Changes that affect humans adversely are called natural hazards. Natural Hazards are elements of circumstances in the Natural environment that have the potential to cause harm to people or property or both. These may be swift or permanent aspects of the respective environmental settings like currents in the oceans or extreme climatic conditions in deserts etc.

Natural hazards become natural disasters when people's lives and livelihoods are destroyed. As compared to natural hazards, **natural disasters** are relatively sudden and cause large scale, widespread death, loss of property and disturbance to social systems and life over which people have a little or no control. Thus, any event can be classed as disaster when the magnitude of destruction and damage caused by it is very high.

Hazard	**Disaster**
Hazard is a threat. A hazard is a dangerous physical condition or event.	Disaster is an event. It is a calamity or tragedy or a consequence of a hazard. Natural hazards that cause great loss to human life and economy are called disasters and cat astrophes. A disaster disrupts the normal function of the society.
Earthquakes, floods, volcanic erruption, landslides, droughts etc. are called natural hazards before they cause great loss of life and damage to property.	It causes damage to property and loss of life but it also disrupts the opportunities of employment.
Small number of people are effected	A large number of people are effected
It may cause injury, loss of life or damage of property.	It causes wide spread loss to life and property.
Earthquakes, floods, volcanoes, tsunami, land slide, drought etc. are natural hazards	It affects the society to such an extent that external aid becomes sate the losses.

Table 1 – Difference between Natural Hazard and Disaster

Every disaster is unique in terms of the local socio-environmental factors that control it, the social response it generates, and the way each social group negotiates with it. There are **three observations on disasters** which are as follows:

- The magnitude, intensity, frequency and damages caused by natural disasters have increased over the years.
- There is a growing concern among people the world over to deal with the menace created by these so that the loss of human life and property can be minimised.
- Significant changes have taken place in the pattern of natural disasters over the years.

Man has been bearing the brunt of natural disasters since ancient times. There are many disasters which man in unable to face or prevent from happening. They are destined to bring their tragic consequences of human

destruction. Due to human intervention in the natural processes, the destructive power and frequency of natural disasters have increased considerably. According to UN statistics, natural disasters kill 1,00,000 persons on an average and cause property damage worth of billions of dollar per year. **Among the top ten natural disaster-prone countries, India stands second after China.**

People used to correlate hazards and disasters. Areas prone to natural hazards were more vulnerable to disasters. Hence, people avoided tampering with the delicate balance that existed in a given ecosystem. People avoided intensification of their activities in such areas and that is how disasters were less damaging.

With the advent of technology and rise in population density in certain parts of the world, human beings tend to intensify their activities into disaster prone areas increasing their vulnerability to disasters. Colonization of flood plains and seaward extension of port cities etc. make them vulnerable to the occurrence of floods, cyclones, hurricanes and tsunamis.

What is vulnerability ?

Vulnerability may be defined as "The extent to which a community, structure, services or geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrains or a disaster prone area." Vulnerabilities can be categorized into physical and socio-economic vulnerability. **Disasters occur when hazards meet vulnerability.**

8.2. DISASTER IN INDIA

India is vast and diverse in terms of its physical and socio-cultural attributes. It is largely due to its vast geographical area, environmental diversities and cultural pluralities, India is struggling with disasters from many years. Its vastness in terms of natural attributes combined with its prolonged colonial past, continuing various forms of social discriminations and also equally large population have enhanced its vulnerability to natural disasters. Killer waves (tsunami) struck the coastal parts of India on 26th December 2004 or the morning of 26th January 2001, when western part of India was badly affected by earthquake or recent flashflood in the Uttrakhand or Cyclone Phalin at Odisha coast. These are just few examples. We always listen such kind of news in print or electronic media that one part of India is affected by flood where as another faces drought. Due to vulnerability of different kinds of disasters, it is said that India is a disaster prone country, the reasons are:

- 85% vulnerable to single or multiple disasters
- 12% is flood prone,
- 8% is vulnerable to cyclones and
- 57% of area lies in high seismic zones
- 40 million hectare prone to flood = ~12% of total area
- 8% area vulnerable to cyclone
- 68% area is susceptible to drought
- Out of 35 states and UTs- 27 are prone to one or more of these events
- Some areas are vulnerable to industrial, chemical and biological disasters

8.3. CLASSIFICATION OF NATURAL HAZARDS

Researchers have been studying disasters for more than a century. The studies reflect a common opinion when they argue that all disasters can be seen as being human-made, their reasoning being that human actions before the strike of the hazard can prevent it developing into a disaster. All disasters are hence the result of human failure to introduce appropriate disaster management measures Hazards are routinely divided into **natural or human-made**, although complex disasters, where there is no single root cause, are more common in developing countries.

(1) Man-made Disasters: Disasters caused by human action, negligence, error, or involving the failure of a system are called human-made disasters. Human-made disasters are in turn categorized as technological or sociological. Technological disasters are the results of failure of technology, such as engineering failures, transport disasters, or environmental disasters. Sociological disasters have a strong human motive, such as criminal acts, stampedes, riots, and war.

(2) Natural Disasters:

Broadly, natural disasters can be classified under four categories (Table 2).

Atmospheric	*Terrestrial*	*Aquatic*	*Biological*
Blizzards Thunderstorms Lightning Tornadoes Tropical Cyclone Drought Hailstorm Frost, Heat Wave or *Loo*.Cold Waves, etc.	Earthquakes Volcanic Eruptions Landslides Avalanches Subsidence Soil Erosion	Floods Tidal Waves Ocean Currents Storm Surge Tsunami	Plants and Animals as colonisers (Locusts, etc.). Insects infestation— fungal, bacterial and viral diseases such as bird flu, dengue, etc.

Table 2 – classification of natural disasters

8.3.1. EARTHQUAKE

An earthquake is a phenomenon that occurs without warning and involves violent shaking of the ground and everything over it. It results from the release of accumulated stress of the moving lithospheric or crustal plates. The occurrence of an earthquake in a populated area may cause numerous casualties and injuries as well as extensive damage to property. **Earthquakes are by far the most unpredictable and highly destructive of all the natural disasters.** Earthquakes that are of tectonic origin have proved to be the most devastating and their area of influence is also quite large. As compared to these, the earthquakes associated with volcanic eruption, rock fall, landslides, subsidence, particularly in the mining areas, impounding of dams and reservoirs, etc. have limited area of influence and the scale of damage. There is a geographic pattern of earthquake around the world at the tectonic plate margins. There are instances where earthquake occurs within the plate also.

India's increasing population and extensive unscientific constructions mushrooming all over, including multistoried luxury apartments, huge factory buildings, gigantic malls, supermarkets as well as warehouses and masonry buildings keep - **India at high risk.** During the last 15 years, the country has experienced 10 major earthquakes that have resulted in over 20,000 deaths. As per the current seismic zone map of the country, **over 59 per cent of India's land area is under threat of moderate to severe seismic hazard. In fact, the entire Himalayan belt is considered prone to great earthquakes of magnitude exceeding 8.0**-; and in a relatively short span of about 50 years, four such earthquakes have occurred: 1897 Shillong (M8.7); 1905 Kangra (M8.0); 1934 Bihar-Nepal (M8.3); and 1950 Assam-Tibet (M8.6). Himalayas is the region of convergence of Indian and Eurasian plates. The Indian plate is moving at a speed of one centimetre per year towards the north and northeastern direction. In the recent past, even **inter-plate boundary areas** have experienced devastating earthquakes, albeit of lower magnitude than the Himalayan earthquakes. **The Koyna earthquake in 1967** led to revision of the seismic zoning map. The occurrence of the **Killari earthquake in 1993** resulted in further revision of the seismic zoning map.

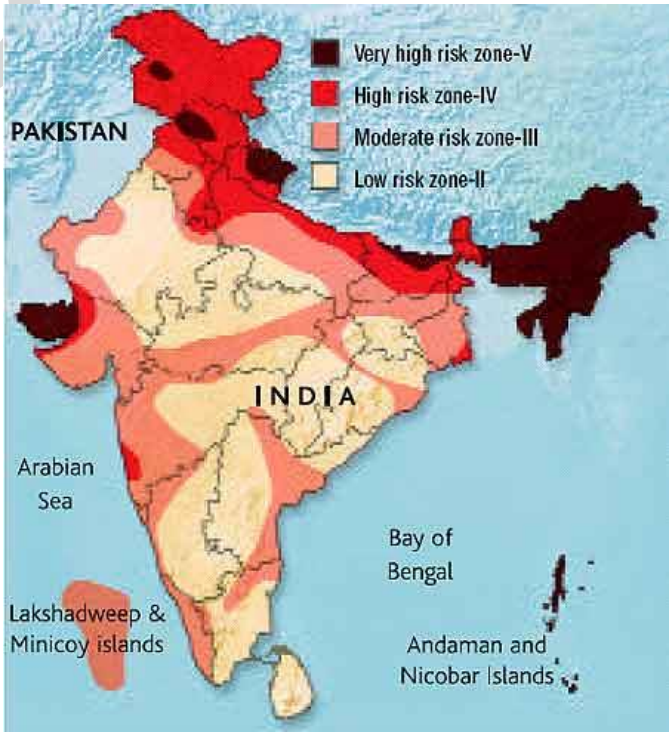
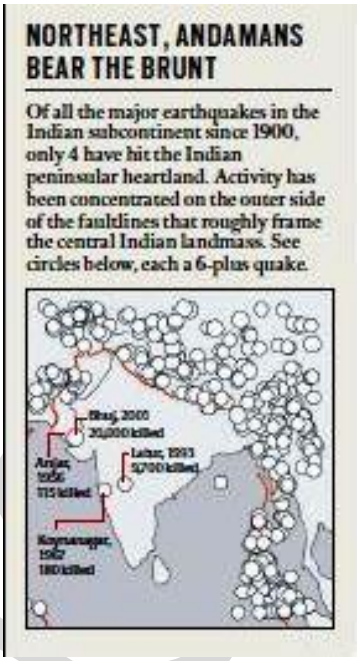


Figure 1: India: Earthquake Hazard Zones

The North-Eastern part of the country continues to experience moderate to large earthquakes at frequent intervals including the two great earthquakes. On an average, the region experiences an earthquake with a magnitude greater than 6.0 every year. The Andaman and Nicobar Islands are also situated on an inter-plate boundary and frequently experience damaging earthquakes.

India is divided into following four earthquake zones as shown in figure 1. There was a change in the earthquake map of India where Very low risk zone and Low risk zone were merged into single 'low risk zone'. Zone IV and Zone V had experienced some of the most devastating earthquakes in India. Areas vulnerable to these earthquakes are the North-east states, areas to the north of Darbhanga and Araria along the Indo-Nepal border in Bihar, Uttaranchal, Western Himachal Pradesh (around Dharamshala) and Kashmir Valley in the Himalayan region and the Kuchchh (Gujarat). Most of the areas that can be considered safe are from the stable landmass covered under the Deccan plateau.



Socio-Environmental Consequences of Earthquakes

Earthquake is often associated with fear and horror due to the **scale, magnitude and suddenness** at which it spreads disasters on the surface of the earth without discrimination. It becomes a calamity when it strikes the areas of high density of population. Following are major impact of earthquake:

- **Damage of property:** when earthquake occurs, all buildings from cottage to palaces and stronger skyscrapers are greatly damaged or totally destroyed. Underground pipelines and railway lines are damaged or broken. Dams on river collapse, resultant floods cause havoc.
- **Human loss:** Duration of tremors of earthquake is normally of only few seconds, but thousands of people may die in this short period. Bihar earthquake of 1934 and Kangra earthquake of 1905, 10,000 and 20,000 people died respectively. The destruction of property was tremendous and could not be estimated properly and exactly.
- **Changes in river courses:** Sometimes river channels are blocked or their courses are changed due to the impact of earthquake.
- **Tsunamis:** are caused by earthquake. It wreaks havoc on settlement of coastal areas. It sinks large ships. Tsunami that occurred on 26-12-2004 near coast of Sumatra (Indonesia) damaged property worth billions of rupees.
- **Fountains of mud:** Due to the intense impact of earthquake hot water and mud appear on the surface and take a form of fountains. In Bihar earthquake of 1934 some cracks and fissures had developed. The fields of farmer were covered by knee-deep mud and the crops were destroyed.
- **Landslides** and avalanches are **triggered**
- Different effects of earthquake are shown in table 3.

On Ground	On Manmade Structures	On water
Fissures	Cracking	Waves
Settlements	Sliding	Hydro-Dynamic Pressure
Landslides	Overturning	Tsunami
Liquefaction	Buckling	Possible China effects
Earth Pressure	Collapse	
Possible Chain effects	Possible China effects	

Table 3 – Effects of Earthquakes

Earthquake Hazard Mitigation

Since earthquake also destroys most of the transport and communication links, providing timely relief to the victims becomes difficult. It is not possible to prevent the occurrence of an earthquake; hence, the next **best option is to emphasis on disaster preparedness and mitigation rather than curative measures** such as:

- Establish earthquake monitoring centres (**seismological centres**) for regular monitoring and fast dissemination of information among the people in the vulnerable areas.
- Preparing a **vulnerability map** of the country and dissemination of vulnerability risk information among the people and educating them about the ways and means minimising the adverse impacts of disasters.
- **Community preparedness:** Community preparedness is vital for mitigating earthquake impact. The most effective way to save you even in a slightest shaking is 'DROP, COVER and HOLD'.

- **Planning:** The Bureau of Indian Standards has published building codes and guidelines for safe construction of buildings against earthquakes. Before the buildings are constructed the building plans have to be checked by the Municipality, according to the laid down **bylaws**. Many existing lifeline buildings such as hospitals, schools and fire stations may not be built with earthquake safety measures. Their earthquake safety needs to be upgraded by retrofitting techniques. The analysis of data from major earthquakes establishes the fact that the casualties here in India are primarily due to building collapse while the similar intensity earthquakes in US or Japan does not lead to such enormous loss of lives as the structures in these countries are built with structural mitigation measures and earthquake-resistant features
- **Public education** is educating the public on causes and characteristics of an earthquake and preparedness measures. It can be created through sensitization and training programme for community, architects, engineers, builders, masons, teachers, government functionaries teachers and students. by preparation of disaster management plans by schools, malls, hospitals etc. and carrying out a mock drill, by preparing documentation on lessons from previous earthquakes and widely disseminating it
- **Engineered structures:** Buildings need to be designed and constructed as per the building by laws to withstand ground shaking. Architectural and engineering inputs need to be put together to improve building design and construction practices. The soil type needs to be analyzed before construction. Building structures on soft soil should be avoided. Buildings on soft soil are more likely to get damaged even if the magnitude of the earthquake is not strong as shown. Similar problems persist in the buildingsconstructed on the river banks which have alluvial soil.
- **Risk transfer instruments –** These should be developed in collaboration with the insurance companies and financial institutions.
- **Encouraging use of Indigenous methods** – Indigenous earthquake-resistant houses like the bhongas in the Kutch Region of Gujarat, dhajji diwari buildings in Jammu & Kashmir, brick-nogged wood frame constructions in Himachal Pradesh and ekra constructions made of bamboo in Assam are increasingly being replaced with modern Reinforced Cement Concrete (RCC) buildings, often without incorporating earthquake resistant features and without compliance to building codes and bye-laws. It is thus necessary to empower communities to ensure the seismic safety of the built environment by encouraging the use of simple, easy and affordable technical solutions and institutional arrangements and making use of indigenous technical knowledge and locally available materials in the construction of earthquake-resistant buildings in suburban and rural areas.
- **Quick and effective response –** Although NDRF battalions have been set up by the government, experience has shown that over 80% search and rescue is carried out by communities itself before the intervention of state machineries and specialized rescue and relief forces. Thus there is a need to give basic training to the community members as it is always the first responder after any disaster.
- **Early Earthquake Warning and Security System** - Chennai-based Structural Engineering Research Centre (CSIR-SERC), a pioneer advanced seismic testing and research laboratory under the Council of Scientific & Industrial Research (CSIR), has completed the testing of the German-developed "Early Earthquake Warning and Security System", which was launched for the first time in India early this year.
- Participation of community at local level in planning, implementation and monitoring process.

Challenges for India in mitigation

- Inadequate numbers of trained and qualified civil engineers, structural engineers, architects and masons proficient in earthquake-resistant design and construction of structures.
- Need for imparting training in earthquake-resistant design and construction to faculty members in professional colleges, for revising the curriculum in professional courses
- Creating public awareness on seismic risk reduction features in non-engineered construction in earthquake-prone areas.
- Carrying out structural safety audit of existing critical lifeline infrastructure and their strengthening and seismic retrofitting in earthquake prone areas.
- Mobilisation of resources including funds and their management

Some **Dos and Don'ts** during and after the earthquake:

- Have a **disaster emergency kit** ready which includes torch, radio, first aid kit, emergency food, chlorine tablets for water purifier, cash and cards etc.

- **Inside the house -** Don't run outside, set your family into-doorways, under table or if they are bedridden, move them under the beds; keep away from windows and chimneys.
- **Outside the house** - Don't go near the buildings, high walls, or electric wires.
- **While driving** - If an earthquake occurs stop driving and keep sitting in the vehicle.
- To be done immediately
  - Put off domestic fire, and all electrical switches.
  - Leave the house if possible and go to open space.
  - Leave the house if a gas leak is detected after the gas is turned off.
  - Save water
  - Untie and free pets and domestic animals (dogs, cats and cattles)
- If trapped under debris
  - Do not light a match.
  - Do not move about or kick up dust.
  - Cover your mouth with a handkerchief or clothing.
  - Tap on a pipe or wall so rescuers can locate you.

8.3.2. TSUNAMI

Earthquakes and volcanic eruptions that cause the sea-floor to move abruptly resulting in sudden displacement of ocean water in the form of high vertical waves are called tsunamis (harbour waves) or seismic sea waves. Normally, the seismic waves cause only one instantaneous vertical wave.

The speed of wave in the ocean depends upon the depth of water. It is more in the shallow water than in the ocean deep. As a result of this, **the impact of tsunami is less over the ocean and more near the coast where they cause large-scale devastations.** When a tsunami enters shallow water, its wave-length gets reduced and the period remains unchanged, which increases the wave height. Sometimes, this height can be up to 15m or more, which causes large-scale destructions along the shores. Thus, these are also called Shallow Water Waves.

After reaching the coast, the tsunami waves release enormous energy stored in them and water flows turbulently onto the land destroying port-cities and towns, structures, buildings and other settlements. The **loss of life and property is likely to be much higher by a tsunami as compared to other natural hazards in the coastal areas due to high population density and centre of economic activities.** Whole coastline of mainland India along with Islands in both oceans is prone to Tsunami disaster.

Combined efforts at the international levels are the possible ways of dealing with these disasters as has been in the case of the tsunami that occurred on 26th December 2004 in which more than 300,000 people lost their lives. India has volunteered to join the International Tsunami Warning System after the December 2004 tsunami disaster.

The Government of India has put in place an **Early Warning System for mitigation** of such oceanogenic disasters under the control of **Indian National Center for Ocean Information Services (INCOIS),** Hyderabad. A state-of-the-art early warning centre was established with the necessary computational and communication infrastructure that enables reception of real-time data from sensors, analysis of the data, generation and dissemination of tsunami advisories following a standard operating procedure. Seismic and sea-level data are continuously monitored in the Early Warning Centre using custom-built software application that generates alarms/alerts in the warning centre whenever a pre-set threshold is crossed. Tsunami warnings/watches are then generated based on pre-set decision support rules and disseminated to the concerned authorities for action, as per pre-decided standard operating procedure. **The efficiency of this end-to-end system was proved during the large under-sea earthquake of 8.4 M that occurred on September 12, 2007 in the Indian Ocean.**

Ministry of Environment and Forests is also implementing Integrated Coastal Zone Management Program, which cohesively considers several coastal problems, such as erosion, pollution, tourism and sediment discharge from rivers and demarcating the vulnerability lines along coastal stretches. It should be emphasized that the island states must have their own coping capacities and adequate capabilities to respond to any emergency, without waiting for assistance from the Central Government. Cyclone-cum-tsunami shelters need to be designed and built in such away that it addresses multi-purpose uses. One other area to be stressed for the mitigation og effects of Tsunami is enhancing the area under mangroves forests as they provde buffer against it. Thus

plantations need to be closely monitored to ensure their survival and growth using state-of-the-art remote sensing technologies.

Dos and Don'ts for Protection from Tsunami

- Before Tsunami
  - **Know the height** of your street above sea level and the distance of your street from the coast or other high-risk waters.
  - **Plan evacuation routes** from your home, school, workplace, or any other place you could be where tsunamis present a risk. If possible, pick areas (30 meters) above sea level or go as far as 3 kilometres inland, away from the coastline.
  - Use a **Weather Radio** or stay tuned to a local radio or television station to keep informed of local watches and warnings.
- **During Tsunami**
  - If you feel an earthquake that lasts 20 seconds or longer when you are in a coastal area, you should drop, cover, and hold on. You should **first protect yourself** from the earthquake damages
  - Gather members of your household and move quickly to higher ground away from the coast.
  - **Move immediately to higher ground,** DO NOT wait for a tsunami warning to be announced. Stay away from rivers and streams that lead to the ocean

8.3.3. TROPICAL CYCLONE

The Indian subcontinent is one of the worst affected regions in the world. The subcontinent with a long coastline of 8041 kilometres is exposed to nearly 10 per cent of the world's tropical cyclones. Of these, the majority of them have their initial genesis over the Bay of Bengal and strike the East coast of India. On an average, five to six tropical cyclones form every year, of which two or three could be severe. **More cyclones occur in the Bay of Bengal than the Arabian Sea and the ratio is approximately 4:1.** Cyclones occur frequently on both the coasts (the West coast - Arabian Sea; and the East coast - Bay of Bengal). An analysis of the frequency of cyclones on the East and West coasts of India between 1891 and 1990 shows that nearly 262 cyclones occurred (92 of these severe) in a 50 km wide strip above the East coast. Less severe cyclonic activity has been noticed on the West coast, where 33 cyclones occurred the same period, out of which 19 of were severe.

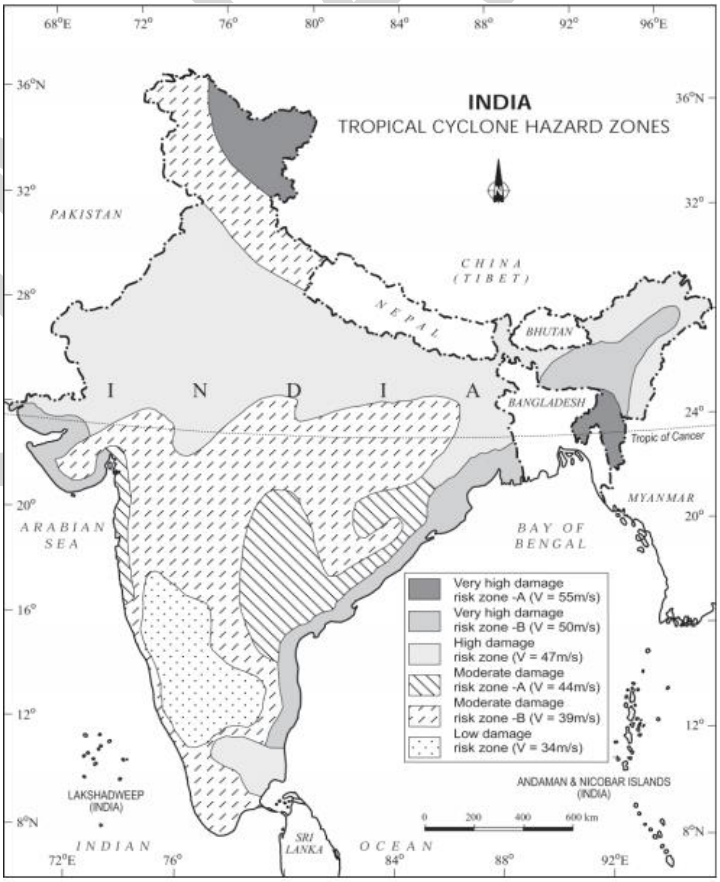


Figure 2: Tropical Cyclone Hazard Zones

Tropical cyclones occur in the months of May-June and October-November. Cyclones of severe intensity and frequency in the North Indian Ocean are bi-modal in character, with their primary peak in November and secondary peak in May. The disaster potential is particularly high during landfall in the North Indian Ocean (Bay of Bengal and the Arabian Sea) due to the accompanying destructive wind, storm surges and torrential rainfall. Of these, storm surges cause the most damage as sea water inundates low lying areas of coastal regions and causes heavy floods, erodes beaches and embankments, destroys vegetation and reduces soil fertility.

Cyclones vary in diameter from 50 to 320 km but their effects dominate thousands of square kilometers of ocean surface and the lower atmosphere. The perimeter may measure 1,000 km but the powerhouse is located within the 100-km radius. Nearer the Eye, winds may hit at a speed of 320 km. Thus, tropical cyclones, characterized by destructive winds, torrential rainfall and storm surges disrupt normal life with the accompanying phenomena of

floods due to the exceptional level of rainfall and storm surge inundation into inland areas. Cyclones are characterized by their devastating potential to damage structures, viz. houses; lifeline infrastructure-power and communication towers; hospitals; food storage facilities; roads, bridges and culverts; crops etc. The most **fatalities come from storm surges and the torrential rain flooding the lowland areas** of coastal territories.

Consequences of Tropical Cyclones

The cyclones cause great damage throughout the entire path of its passage. The strong cyclonic winds that precede and follow the cyclone blow away houses ranging from small huts to concrete structures and houses made of steel and stones. Trees, electric poles are uprooted and smashed. The heavy and torrential rains then cause the floods which play further havoc all around. **The wind's passing over ocean or sea give rise to mighty waves called 'storm surges'** they strike the coastal areas like a huge wall of water and cause damage up to 10-15 km away from the coast towards the land. It then plays havoc with roads, fields, houses, factories, electric poles and human settlements on the coasts. The landslides prompted by cyclonic conditions become more dangerous and destructive.

Some dos and don'ts before, during and after the cyclone

- Listen to the radio for advance information and advice
- Keep considerable margin of time for safety.
- A cyclone may change direction, speed, or intensity within a few hours, so stay tuned to the radio for updated information.
- When the storm strikes.
    - Stay in the house and take shelter in the stronger portion of your house.
    - Listen to the radio and follow instructions.
    - Open windows of the safe portion of the house if the roof begins to lift.
    - Find shelter if you are in open at the hitting time of the cyclone.
    - Do not go out of your house or to a beach during or lay down along an elevated footpath in open field the storm. Cyclone often generates large surges in these oceans or lakes.

8.3.4. FLOODS

With the arrival of Monsoon, people living in **40 million hectares area** of the country become extremely nervous. No one knows when there will be a flood in the river and their hard earned belongings will be washed away. In comparison to other disasters flood cause more damage to life and property. **Twenty percent of deaths caused by floods in the World occur in India.**

The inundation of an area by water is called a flood. Inundation of land and human settlements by the rise of water in the channels and its spill-over presents the condition of flooding. Unlike other natural disasters, the causes of floods are well established. Floods are relatively slow in occurrences and often, occur in well-identified regions and within expected time in a year.

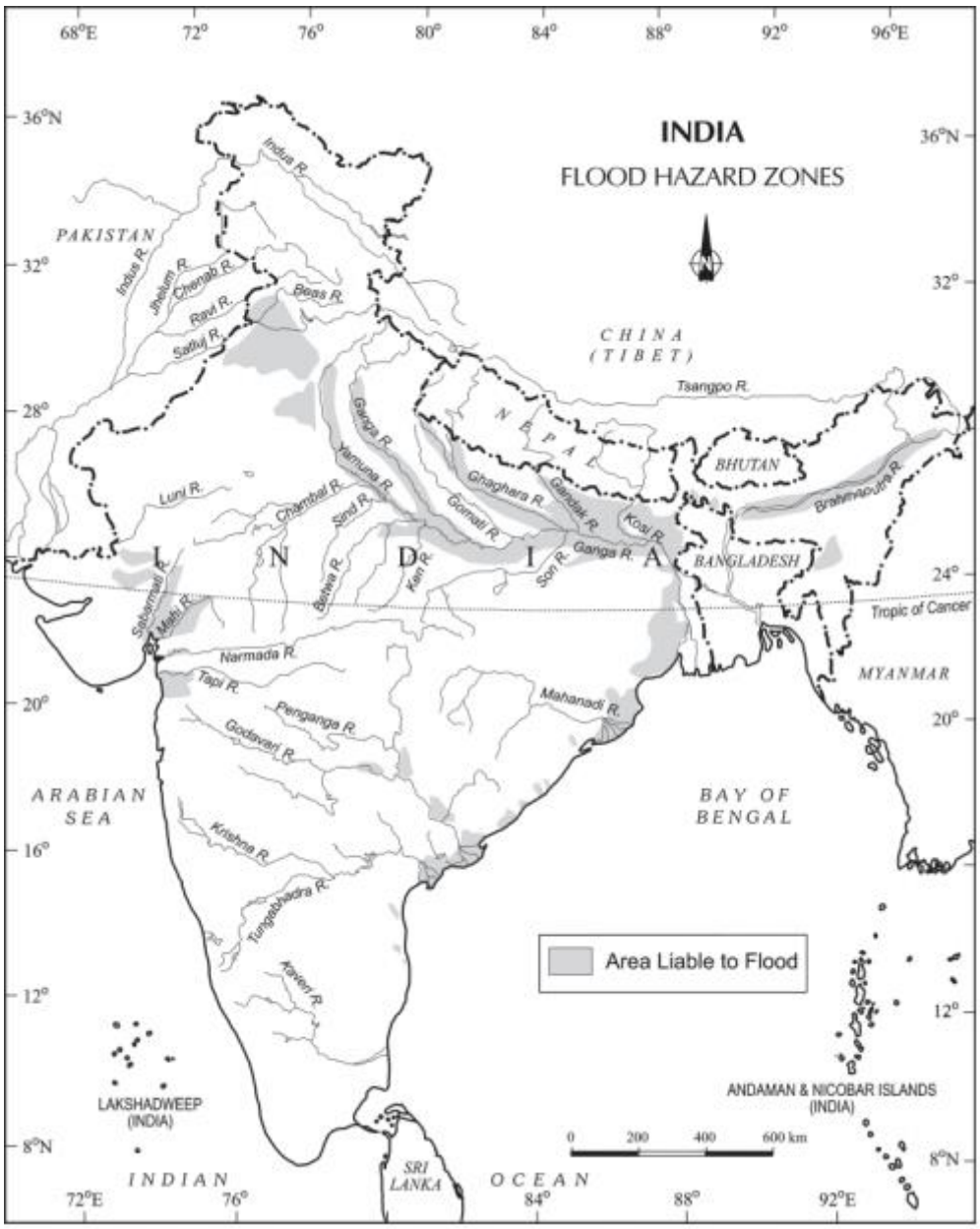


Figure 3 – Flood Hazard zones

Though floods occur frequently over wide geographical area having disasterous ramifications in many parts of the world, floods in the South, Southeast and East Asian countries, particularly in China, India and Bangladesh, are frequent and equally disastrous. In India, around 40 million hectare area is flood-prone, which is one eighth of the total area (figure 3). The most flood prone areas are the Brahmputra, Ganga and Indus basins. As far as states are concerned, Uttar Pradesh, Bihar, West Bengal and Orissa are the most flood affected states followed by Haryana, Punjab and Andhra Pradesh. Nowadays Rajasthan and Gujarat also feel the fury of floods. Karnataka and Maharashtra are no longer immune to floods.

Types of flooding

- **According to Duration**
  - Slow-Onset Flooding
  - Rapid-Onset Flooding
  - Flash Flooding
- **According to Location**
  - Coastal Flooding
  - Arroyos Flooding
  - River Flooding
  - Urban Flooding

Unlike other natural disasters, **human beings play an important role in the genesis as well as spread of floods**. Indiscriminate deforestation, unscientific agricultural practices, disturbances along the natural drainage channels and colonisation of flood-plains and river-beds are some of the human activities that play an important role in increasing the intensity, magnitude and gravity of floods. The causes of flood are as follows:

Natural causes

- **Heavy rainfall**: Heavy rain in the catchment area of a river causes water to over flow its banks, which results in the flooding of nearby areas.
- **Sediment deposition**: River beds become shallow due to sedimentation. The water carrying capacity of such river is reduced. As a result the heavy rainwater over flow the river banks.
- **Cyclone**: Cyclone generated seawaves of abnormal height spreads the water in the adjoining coastal areas. In October 1994 Orissa cyclone generated severe floods and caused unprecedented loss of life and property.
- **Change in the course of the river**: Meanders and change in the course of the river cause floods.
- **Tsunami**: Large coastal areas are flooded by rising sea water, when a tsunami strikes the coast.
- **Lack of Lakes** - Lakes can store the excess water and regulate the flow of water. When lakes become smaller, their ability to regulate the flow become less and hence flooding.

Anthropogenic causes

- **Deforestation**: Vegetation hampers the flow of water and forces it to percolate in the ground. As a result of deforestation, the land becomes obstruction free and water flows with greater speed into the rivers and causes flood.
- **Interference in drainage system**: Drainage congestion caused by badly planned construction of bridges, roads, railway tracks, canals etc. hampers the flow of water and the result is flood. The areas which were essentially created by the storm water drains to let their flood waters pass freely being tress-passed for developmental purposes result in obstruction of water flow and thus contributed immensely to the fury of floods.
- **International dimension** - The rivers originating in China, Nepal and Bhutan cause severe floods in the states of Uttar Pradesh, Bihar, West Bengal, Arunachal Pradesh and Assam. For flood management (FM), cooperation with the neighbouring countries viz. China, Nepal and Bhutan is essential
- **Population pressure** - Because of large amount of people, more materials are needed, like wood, land, food, etc. This aggravates overgrazing, over cultivation and soil erosion which increases the risk of flooding.
- **Poor Water and Sewerage Management** - Old drainage and sewerage system has not been overhauled nor is it adequate now .All the drainage and sewer system in many parts of Delhi has collapsed resulting in flooding. This can be seen during rainy seasons every year.
- Lack of attention to the nature of hydrological system
- Lack of flood control measures
- Multiple authorities in a city but owning responsibility by none

What are Flash Floods?

Flash floods are short-term events, occurring within 6 hours of the causative event (heavy rain, dam break, levee failure, rapid, snowmelt and ice jams) and often within 2 hours of the start of high intensity rainfall. A flash flood is characterized by a rapid stream rise with depths of water that can reach well above the banks of the creek. Flash flood damage and most fatalities tend to occur in areas immediately adjacent to a stream or arroyo. Additionally, heavy rain falling on steep terrain can weaken soil and cause mud slides, damaging homes, roads and property.

In June 2013, a multi-day cloudburst centered on Uttarakhand caused devastating flash floods and landslides in the country's worst natural disaster since the 2004 tsunami.

Consequence and Control of Floods

- **Frequent inundation** of agricultural land and human settlement has serious consequences on the national economy and society.
- Floods do not only destroy valuable crops every year but these also damage physical infrastructure such as roads, rails, bridges and human settlements.
- **Millions of people are rendered homeless** and are also washed down along with their cattle in the floods.

- Spread of diseases like cholera, gastro-enteritis, hepatitis and other water-borne diseases spread in the flood-affected areas.
- Floods also make a few positive contributions. Every year, **floods deposit fertile silt over agricultural fields** which is good for the crops.

Flood control measures

- **Reservoirs**: By constructing reservoirs in the courses of rivers could stores extra water at the time of flood. Such measures adopted till now however, have not been successful. Dams built to control floods of Damodar could not control the flood.
- **Embankments**: By building flood protection embankments, floods water can be controlled from overflowing the banks and spreading in nearby areas. Building of embankments on Yamuna, near Delhi, has been successful in controlling the flood.
- **Afforestation**: The furry of flood could be minimized by planting trees in catchment areas of rivers.
- **Restoration of original drainage system:** Drainage system is generally choked by the construction of roads, canals railway tracks etc. Floods could be checked if the original form of drainage system is restored.

Dos and don'ts before, during and after the flood

- Avoid building in flood prone areas unless you elevate and reinforce your home.
- Listen to the radio for advance information
- Be aware that flash flooding can occur. If there is any possibility of a flash flood, move immediately to higher ground. Do not wait for instructions
- Disconnect all electrical appliances, move all valuable household goods out of reach of flood water.
- Switch off electricity and gas, in case you have to leave the house.
- Lock all door and windows if you have to leave the house.
- Do not enter flood water on foot or in a vehicle as far as possible.

8.3.5. URBAN FLOODS

Urban flooding is significantly different from rural flooding as urbanization leads to developed catchments, which increases the flood peaks from 1.8 to 8 times and flood volumes by up to 6 times. Consequently, **flooding occurs very quickly due to faster flow times** (in a matter of minutes). Urban areas are densely populated and people living in vulnerable areas suffer due to flooding, sometimes resulting in loss of life. It is not only the event of flooding but the secondary effect of exposure to infection also has its toll in terms of human suffering, loss of livelihood and, in extreme cases, loss of life.

The un-even distribution of rain fall coupled with Mindless urbanisation, encroaching upon and filling up natural drainage channels and urban lakes to use the high-value urban land for buildings are the cause of urban flooding. The illegal filling of urban water bodies in cities like Calcutta, Delhi, and Hyderabad etc is a rampant. The urban area is paved with roads etc and the discharge of heavy rain can't be absorbed into the ground due to drainage constraints leads to flooding of streets, underpasses, low lying areas and storm drains. The recent floods in Chennai also serves as a reminder of the unwanted effects of unplanned urbanization

Urban areas are also centres of economic activities with vital infrastructure which needs to be protected 24x7. In most of the cities, damage to vital infrastructure has a bearing not only for the state and the country but it could even have global implications. Major cities in India have witnessed loss of life and property, disruption in transport and power and incidence of epidemics. Most city areas around rivers are flooded during monsoon period. Mumbai floods in 2006 caused havoc in the whole city. Therefore, management of urban flooding has to be accorded top priority.

Increasing trend of urban flooding is a universal phenomenon and poses a great challenge to urban planners the world over. Problems associated with urban floods range from relatively localized incidents to major incidents, resulting in cities being inundated from hours to several days. Therefore, the impact can also be widespread, including temporary relocation of people, damage to civic amenities, deterioration of water quality and risk of epidemics.

Dos and don’ts before, during and after the flood

Before floods

- Do not litter waste, plastic bags, plastic bottles in drains
- Try to be at home if high tide and heavy rains occur simultaneously
- Listen to weather forecast.
- Evacuate low line areas and shift to safer places.
- Make sure that each person has lantern, torch, some edibles, drinking water, dry clothes and necessary documents while evacuating or shifting.

In the Flood Situation

- Shift to a safer place.
- Be at safe place and they try to collect correct information.
- Switch of electrical supply and don’t touch open wires.
- Don’t get carried away by rumors and don not spread rumors.

Don'ts

- Don't walk through flowing water - currents can be deceptive, and shallow, fast moving water can knock you off your feet.
- Don't swim through fast flowing water.
- Don't drive through a flooded area.
- Don't eat any food that has come into contact with flood water.
- Don't scrub or brush mud and other deposits from materials.
- Never turn on ceiling fixtures if ceiling is wet.
- Don't remove standing water in a basement too fast. If the pressure is relieved too quickly it may put undue stress on the walls.

A cloudburst is a sudden downpour within a radius of few kilometres. It usually lasts no longer than few minutes but is capable of flooding the area. Rainfall from a cloudburst is usually over 100 mm per hour. This leads to flash floods/ landslides, house collapse, dislocation of traffic and human casualties on large scale.

Cause: The Cumulonimbus is a tall cloud that contains very high, unpredictable winds. Such clouds are associated with thunderstorms. Typically these are the clouds that are usually responsible for Cloudbursts. Most Cloudbursts occur in association with thunderstorms. In such type of storms there are strong uprushes of air. These updrafts are filled with turbulent wind pockets that shove the small raindrops around leading to collisions between raindrops. The collisions lead to conglomerations and large-sized drops are formed. The forceful upward rush of air also prevents the condensing raindrops from falling downwards. So instead of falling down to Earth the water droplets are pushed upwards till a large amount of water accumulates at a high level. Eventually all updrafts become weak and collapse. With nothing to push it up, the entire water falls down almost all at once.

Hilly areas are more prone to cloud burst. The topographical conditions like steep hills favour the formation of these clouds. And also the devastations, as water flowing down the steep slopes bring debris, boulders and uprooted trees with great velocity damaging any structure that comes in their way.

In one of India's worst cloudbursts on 26 July 2005, Mumbai was completely paralysed. Approximately 950 mm of rainfall was recorded in India's financial capital over a span of eight to ten hours. Leh recorded over 12 mm of rainfall in just few minutes on August 6, 2010 cloudburst, that at least 1000 dead, and hundreds injured.

There is no satisfactory technique for anticipating the occurrence of cloud bursts because of their small scale. A very fine network of radars is required to be able to detect the likelihood of a cloud burst and this would be prohibitively expensive. Only the areas likely to receive heavy rainfall can be identified on a short range scale. Much of the damage can be avoided by way of identifying the areas and the meteorological situations that favour the occurrence of cloud bursts.

8.3.6. DROUGHTS

The term 'drought' is applied to an **extended period when there is a shortage of water availability** due to inadequate precipitation, excessive rate of evaporation and over-utilisation of water from the reservoirs and other storages, including the ground water.

This is different type of agony but painful. To see domestic animals to die of hunger and thirst before one's own eyes; to send beloved members of the family in search of employment to far off places in extremely uncertain and exploitative conditions, reduction in diet to reduce the already meager diet, to wander in search of work all day long in relief works and return rejected and empty-handed in the night, these are some of the heart rending scenes from the drought affected areas of India.

Drought is a complex phenomenon as it involves elements like

- precipitation, evaporation, evapotranspiration
- ground water, soil moisture, storage and surface run-off
- agricultural practices, particularly the types of crops grown
- Socio-economic practices and ecological conditions.

Meteorological Drought	• When there is a prolonged period of inadequate rainfall marked with mal-distribution of the same over time and space. • Rainfall less than 90 per cent of average is categorized as meteorological drought.
Agricultural Drought	• It is characterised by low soil moisture that is necessary to support the crops, thereby resulting in crop failures • If an area has more than 30 per cent of its gross cropped area under irrigation, the area is excluded from the drought-prone category. • An extreme agricultural drought can lead to a famine, which is a prolonged shortage of food in a restricted region causing widespread disease and death from starvation. This is why some times in Hindi language famine Akal and Anavrishty are also used for drought. • The government also declares on area affected by drought, if more than 50 percent crop loss happens in an area due to meteorological condition.
Hydrological Drought	• When the availability of water in different storages and reservoirs like aquifers, lakes, reservoirs, etc. falls below what the precipitation can replenish
Ecological Drought	• When the productivity of a natural ecosystem fails due to shortage of water and as a consequence of ecological distress, damages are induced in the ecosystem.

Table 4 – different types of droughts

Drought Mathematics

The following criteria have been set by the Indian Meteorological Division (IMD) for identifying the drought.

- **Onset of drought:** Deficiency of a particular year's rainfall exceeding 25 per cent of normal.
- **Moderate drought:** Deficit of rainfall between 26-50 per cent of normal.
- **Severe drought:** Deficit of rainfall more than 50 per cent of normal.

Impact of drought

- Droughts cause scarcity of food and water.
- People die of hunger, malnutrition and epidemics.
- People are forced to migrate from their area of residence.
- Crops fail due to scarcity of water.
- Cattle die because fodder and water are not easily available.
- Farmers are deprived of their employment.
- People leave their villages with their families for a long, unknown and uncertain journey in the pursuit of food, water, green fodder and employment.

Drought Prone Areas in India

Droughts and floods are the two accompanying features of Indian climate. According to some estimates, nearly 19 per cent of the total geographical area of the country and 12 per cent of its total population suffer due to drought every year. About 30 per cent of the country's total area is identified as drought prone. It is common to

see flood and drought at same time in different region. It is also common that same region faces drought in one season and flood in another season. This is attributed to spatial and temporal unpredictability in the monsoon behavior. Recently IMD has decided to drop the word 'drought' and replace it with 'deficient' to describe the bad monsoon. It said that it was never the mandate of IMD to declare drought and it is on the state government to decide as droughts are of various types – hydrological, agricultural etc. On the basis of severity of droughts, India can be divided into the 3 regions as shown in table 5.

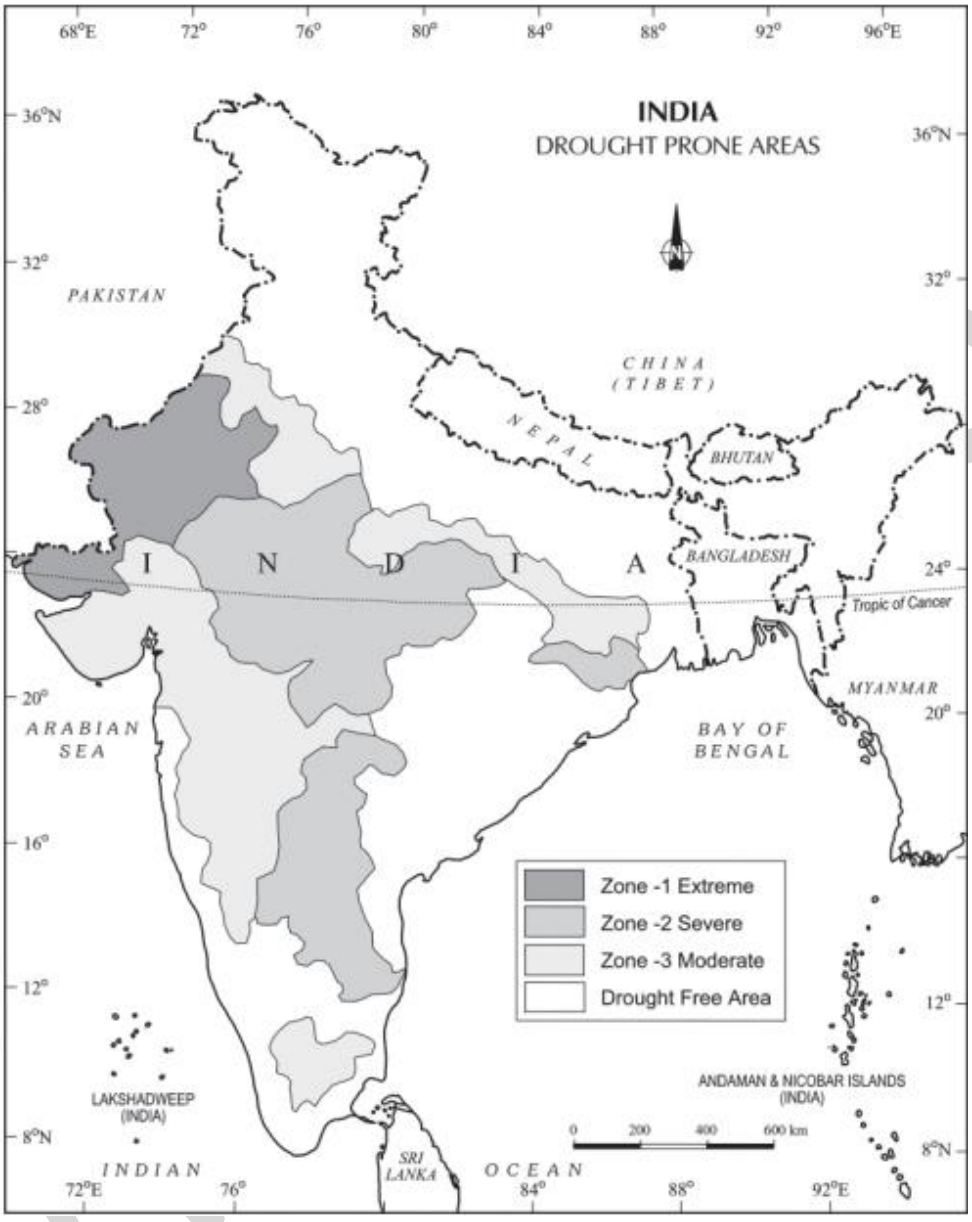


Figure 4 – Drought prone areas

Extreme Drought Affected Areas	• Most parts of Rajasthan, particularly areas to the west of the Aravali hills, i.e. Marusthali and Kachchh regions of Gujarat fall in this category. • The districts like Jaisalmer and Barmer from the Indian desert that receive less that 90 mm average annual rainfall.
Severe Drought Prone Area	• Parts of eastern Rajasthan, most parts of Madhya Pradesh, eastern parts of Maharashtra, interior parts of Andhra Pradesh and Karnataka Plateau, northern parts of interior Tamil Nadu and southern parts of Jharkhand and interior Odisha
Moderate Drought Affected Area	• Northern parts of Rajasthan, Haryana, southern districts of Uttar Pradesh, the remaining parts of Gujarat, Maharashtra except Konkan, Jharkhand and Coimbatore plateau of Tamil Nadu and interior Karnataka

Table 5 – Drought prone regions of India

Consequences of Drought

- Droughts have cascading effects on various other aspects of environment and society.
- Crop failure leading to scarcity of food grains, inadequate rainfall, resulting in shortage of water, and often shortage in all the three is most devastating.
- Large-scale death of cattle and other animals, migration of humans and livestock are the most common sight.
- Scarcity of water compels people to consume contaminated water resulting in spread of many waterborne diseases like gastro-enteritis, cholera, hepatitis, etc.

Measures to cope with Drought

- **Drought Monitoring**: It is continuous observation of the rainfall situation, availability of water in the reservoirs, lakes, rivers etc and comparing with the existing water needs in various sectors of the society.
- Distribution of safe drinking water, medicines for the victims and availability of fodder and water for the cattle and shifting of the people and their livestock to safer places
- Water management is the most crucial long-term step for fighting drought.
- Suitable farming methods for arid areas: By adopting the following methods it is possible to mitigate the intensity of drought. The methods are: Production of coarse and hardy cereals; conservation of soil moisture by deep ploughing, storing water behind small dams, collecting water in ponds and tanks and use of sprinklers for irrigation.
- Sowing drought resistant crops: By sowing drought resistant crops of cotton, Moong, pearl millet, wheat etc, the impact of drought could be mitigated to a certain extent.
- Rain water harvesting: Collection of each and every drop of rain could help in coping with the drought.
- By making high bunds around the fields, adoption of terrace cultivation, planting trees on the bunds of fields, the use of rainwater can be maximised.
- Water can also be conserved by taming the irrigation canals with mortar and bricks.
- Small quantity of water can irrigate comparatively larger area by using drip irrigation and sprinkler methods.
- Identification of ground water potential in the form of aquifers, transfer of river water from the surplus to the deficit areas, and particularly planning for inter-linking of rivers and construction of reservoirs and dams.
- **Livelihood planning** identifies those livelihoods which are least affected by the drought. Some of such livelihoods include increased off-farm employment opportunities, collection of non-timber forest produce from the community forests, raising goats, carpentry etc.
- **Drought planning**: the basic goal of drought planning is to improve the effectiveness of preparedness and response efforts by enhancing monitoring, mitigation and response measures.

8.3.7. LANDSLIDES

India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes. The slow motion of the Indian crust, about 5 cm/year accumulates stress to which natural disasters are attributed. Some landslides make unique and unparalleled catastrophes. **Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India.** Besides the Himalayas, the Northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyans, in that order, covering about 15 % of the landmass. The Himalayas alone count for landslides of every fame, name and description- big and small, quick and creeping, ancient and new. The Northeastern region is badly affected by landslide problems of a bewildering variety.

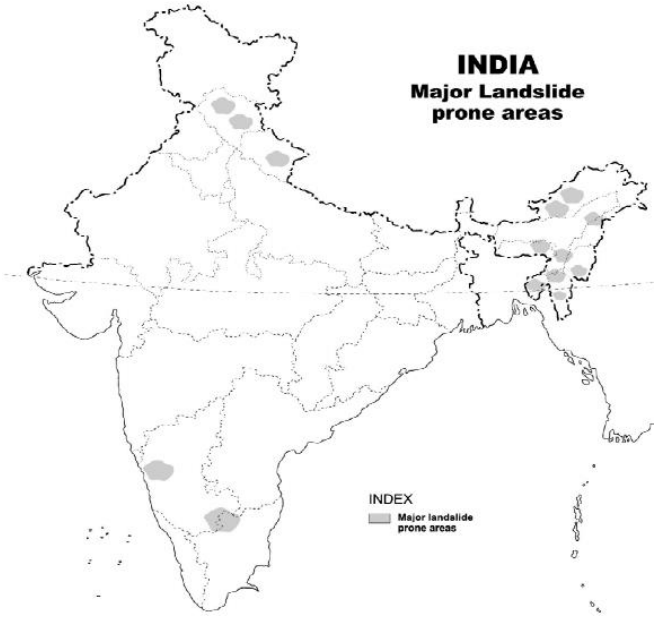


Figure 5: Major Landslide Prone Areas

Landslides in the Darjeeling district of West Bengal as also those in Sikkim, Mizoram, Tripura, Meghalaya, Assam, Nagaland and Arunachal Pradesh pose chronic problems, causing recurring economic losses worth billions of rupees. A different variety of landslides, characterized by a lateritic cap, pose constant threat to the Western Ghats in the South, along the steep slopes overlooking the Konkan coast besides Nilgiris, which is highly landslide prone.

On the basis of past experiences, frequency and certain causal relationships with the controlling factors like geology, geomorphic agents, slope, land-use, vegetation cover and human activities, **India has been divided into a number of vulnerability zones** as shown in table.

Very High Vulnerability Zone	Highly unstable, relatively young mountainous areas in the Himalayas and Andaman and Nicobar, high rainfall regions with steep slopes in the Western Ghats and Nilgiris, the north-eastern regions, along with areas that experience frequent ground-shaking due to earthquakes, etc. and areas of intense human activities, particularly those related to construction of roads, dams, etc. are included in this zone.
High Vulnerability Zone	Areas that have almost similar conditions to those included in the very high vulnerability zone are also included in this category. **The only difference between these two is the combination, intensity and frequency of the controlling factors.** All the Himalayan states and the states from the north-eastern regions except the plains of Assam are included in the high vulnerability zones.
Moderate to Low Vulnerability Zone	Areas that receive less precipitation such as TransHimalayan areas of Ladakh and Spiti (Himachal Pradesh), undulated yet stable relief and low precipitation areas in the Aravali, rain shadow areas in the Western and Eastern Ghats and Deccan plateau also experience occasional landslides. Landslides due to mining and subsidence are most common in states like Jharkhand, Orissa, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Goa and Kerala.
Other Areas	The remaining parts of India, particularly states like Rajasthan, Haryana, Uttar Pradesh, Bihar, West Bengal (except district Darjiling), Assam (except district Karbi Anglong) and Coastal regions of the southern States are safe as far as landslides are concerned.

Causes of landslides

- **Heavy rain:** Heavy rain is the main cause of landslides.
- **Deforestation:** Deforestation is another major cause of landslides. Tree, brushes and grasses keep the soil particles compact. Mountain slope looses their protective cover by felling of trees. The rain water flows on such slopes with unempeded speed.
- **Earthquakes and volcanic explosions:** Earthquake is a common feature in the Himalaya. Tremors destabilize the mountains and the rocks tumble downwards. Volcanic explosions also trigger landslides in the mountainous areas.
- **Building of roads:** Roads are built in mountainous areas for development. During the process of the construction of road, a large amount of rocks and debris has to be removed. This process dislodges the rock structure and changes the angle of slopes. Consequently landslides are triggered.
- **Shifting agriculture:** In the North Eastern part of India, the number and frequency of landslides has increased due to the practice of shifting agriculture.
- **Construction of houses and other buildings:** For giving shelter to the ever-increasing population and promotion of tourism more and more house and hotels are being built. In building processes large amount of debris created. This causes the landslides.

Impact of landslides

- Degrading of environment: Landslides are degrading the environment of mountains. **Natural beauty is diminishing** slowly and slowly.
- Sources of water are **drying up**.
- Diversion of river courses due to landslides can also lead to **flood** and loss of life and property.
- Roadblocks, destruction of railway lines and channel blocking due to rock-falls have far-reaching consequences on **economic and social life**.
- **Life and property** are lost

The problem needs to be tackled for mitigation and management for which hazard zones have to be identified and specific slides to be stabilized and managed in addition to monitoring and early warning systems to be placed at selected sites.

- It is always advisable to adopt **area-specific measures** to deal with landslides.
- **Hazard mapping** should be done to locate areas commonly prone to landslides.
- **Restriction on the construction** and other developmental activities such as roads and dams, limiting agriculture to valleys and areas with moderate slopes, and control on the development of large settlements in the high vulnerability zones, should be enforced.
- Promote large-scale **afforestation programmes** and construction of bunds to reduce the flow of water.
- **Terrace farming** should be encouraged in the northeastern hill states replacing Jhumming or shifting cultivation.
- **Retaining walls** can be built of mountain slopes to stop land from slipping.

Dos and Don'ts

- Keep drains clean,
- Direct storm water away from slopes,
- Inspect drains for - litter, leaves, plastic bags, rubble etc.
- Keep the weep holes open.
- Don't let the water go waste or store above your house.
- Grow more trees that can hold the soil through roots,
- Identify areas of rock fall and subsidence of buildings, cracks that indicate landslides and move to safer areas. Even muddy river waters indicate landslides upstream.
- Notice such signals and contact the nearest District Head Quarters.
- Ensure that toe of slope is not cut, remains protected, don't uproot trees unless revegetation is planned.

8.4. BIOLOGICAL DISASTERS

Biological disasters might be caused by epidemics, accidental release of virulent microorganism(s) or Bioterrorism (BT) with the use of biological agents such as anthrax, smallpox, etc. In recent times travelling has become easier. More and more people are travelling all over the world which exposes the whole world to epidemics.

In India, the major sources of epidemics can be broadly categorized as follows:

a) Water-borne diseases like cholera (and forms of gastroenteritis), typhoid, Hepatitis A, Hepatitis B etc - major epidemics of such diseases have been recorded in the past and continue to occur;
b) Vector-borne (often mosquito-borne) epidemics like dengue fever, chikungunya fever, Japanese encephalitis, malaria, kala-azar etc, which usually occur in certain regions of the country;
c) Person to person transmission of diseases e.g. AIDS and other venereal diseases; and
d) Air-borne diseases like influenza and measles that can also be transmitted through fomites (used clothes etc.).

In addition to the above, there are certain types of emerging infectious diseases such as epidemic of Severe Acute Respiratory Syndrome (SARS), which had occurred in China or the recent outbreak of avian flu in poultry in certain parts of the country and which has the potential of being transmitted to human beings. Epidemics due to the Dengue virus have occurred in many metropolitan cities of India and outbreak of various other types of viral diseases is also a recurring phenomena.

Epidemics often take place due to poor sanitary conditions leading to contamination of food and water or due to inadequate disposal of human or animal carcasses in post disaster situations. They become real dangers during floods and earthquakes. Sometimes, poor solid waste management may create epidemics like plague. Incidence of plague is quite uncommon now but it can still occur claiming many human lives and disrupting normal life as it did in Surat in 1994.

Its Consequences

- It can result dit in heavy mortalities in the short term leading to a depletion of population with a corresponding drop in economic activity
- It leads to diversion of substantial resources of an economy to contain the disaster.

Challenges

The essential challenges posed by natural and artificial outbreaks of disease (bioterrorism) include

- the development of mechanisms for prompt detection of incipient outbreaks
- isolation of the infected persons and the people they have been in contact with
- mobilisation of investigational and therapeutic countermeasures
- international collaboration as epidemics do not respect national borders

Steps required

- **Legal framework** - The Epidemic Diseases Act was enacted in 1897 and needs to be repealed. This Act does not provide any power to the centre to intervene in biological emergencies. It has to be substituted by an Act which takes care of the prevailing and foreseeable public health needs including emergencies such as BT attacks and use of biological weapons by an adversary, cross-border issues, and international spread of diseases
- **Operational framework** - At the national level, there is no policy on biological disasters. The existing contingency plan of MoH&FW is about 10 years old and needs extensive revision. All components related to public health, namely apex institutions, field epidemiology, surveillance, teaching, training, research, etc., need to be strengthened.
- **Command, control and coordination** - One of the lessons learned during the plague outbreak in Surat in 1994 and avian influenza in 2006 is the need to strengthen coordination with other sectors like animal health, home department, communication, media, etc., on a continuous basis for the management of outbreaks of this nature
- **Augmentation in human resource -** There is a shortage of medical and paramedical staff at the district and sub-district levels. There is also an acute shortage of public health specialists, epidemiologists, clinical microbiologists and virologists. There have been limited efforts in the past to establish teaching/training institutions for these purposes.
- **Basic infrastructural setup –** Biosafety laboratories for prompt diagnosis, network of sub centres, PHCs and CHCs, dispensaries with stockpile of essential vaccines and medicines need to be expanded to handle epidemic.

8.5. NUCLEAR HAZARDS

With increased emphasis on power generation through nuclear technology, the threat of nuclear hazards has also increased. The Department of Atomic Energy (DAE) has been identified as the nodal agency in the country in respect of manmade radiological emergencies in the public domain. Nuclear facilities in India have adopted internationally accepted guidelines for ensuring safety to the public and environment. A crisis management system is also in place to take care of any nuclear hazard. In addition to the other types of emergency response plans in place within the facility to handle local emergencies, response plans have also been drawn up for handling such emergencies in the public domain, which are called as “offsite Emergencies”. These plans - drawn up separately in detail for each site - which are under the jurisdiction of the local district administration, cover an area of about 16 km radius around the plant or the offsite Emergency Planning Zone.

8.6. SLOW ONSET DISASTERS

Disasters can also be classified as 'slow onset' disasters and 'rapid onset' disasters. Earthquakes, cyclones, floods, tsunamis would fall under the category of rapid onset disasters; climate change (global warming), desertification, soil degradation, and droughts, would fall under the category of slow onset disasters. Slow onset disasters are also termed as 'Creeping Emergencies'. It may be added that with 'prevention' forming an integral part of the 'management cycle', slow onset disasters like global warming, and desertification must find adequate reflection in disaster preparedness - these phenomena gradually erode the 'health' of ecosystems and expose societies to the vagaries of nature. Unlike the rapid onset disasters, their impact is not felt immediately; however societies lose their ability to derive sustenance from their surroundings, over a period of time. Development policies and the manner in which they are implemented are some of the main reasons for the slow onset disasters.

8.7. INDUSTRIAL DISASTERS

Among the manmade disasters, probably the most devastating (after wars) are industrial disasters. These disasters may be caused by chemical, mechanical, civil, electrical or other process failures in an industrial plant due to accident or negligence, which may cause widespread damage within and/or outside the plant. The worst example globally was the Methyl Iso-cynate gas leak in 1984 from the Union Carbide Factory in Bhopal which has so far claimed more than 20,000 lives and injured several lakh persons besides stunting the growth of a generation born from the affected population. This disaster triggered a completely new legal regime and practices for preventing such disasters.

In the pre-Bhopal Gas Tragedy era, industrial safety was governed by legislations like the Factories Act, 1948 and the Explosives Act, 1884. These laws proved to be inadequate to provide safety to workers as well as to the people living in the surrounding areas. After the Bhopal Gas Tragedy, a new chapter was inserted in the Factories Act, 1948 dealing with hazardous processes. The Environment Protection Act, 1986 was enacted. More importantly, several Rules were promulgated under the Act.

About 1633 major industrial hazard units are located in 245 districts in 19 States/UTs. Stringent environmental protection laws have prevented major industrial disasters after Bhopal, but minor disasters do take place on and off site and also during transportation of hazardous materials, which claim a number of lives each year besides creating environmental problems. Industrial disasters are a major concern today because of increase in the pace of industrialization. It is reported that more than 1140 workers lost their lives and 48,000 workers suffered injuries in factories in 2005. The figure would be more if one includes the civilians who have lost their lives due to accidents in manufacturing processes, storage and transportation of hazardous material. With rapid industrialization, the threat of industrial disasters has increased. However, in spite of the existence of a large number of laws, their enforcement has left much to be desired.

8.8. DISASTER MANAGEMENT

For a long time, geographical literature viewed disasters as a consequence of natural forces; and human beings were treated as innocent and helpless victims in front of the mighty forces of nature. But natural forces are not the only causes of disasters. **Disasters are also caused by some human activities**. Landslides and floods due to deforestation, unscientific land use and construction activities in fragile areas are some of the disasters that are the results of indirect human actions. While others such as **Bhopal Gas tragedy**, Chernobyl nuclear disaster, wars, **release of CFCs** (Chlorofluorocarbons) and increase of green house gases, environmental pollutions are results of direct human actions.

Human-made disasters have increased both in their numbers and magnitudes over the years and concerted efforts are on at various levels to prevent and minimise their occurrences. Though the success has been only nominal so far, it is possible to prevent some of these disasters created by human actions. As opposed to this, very little is possible to prevent natural disasters; therefore, the best way out is to emphasise on natural disaster mitigation and management. **National Institute of Disaster Management, (NIDM)** India, **Earth Summit** at Rio de Janeiro, Brazil, 1993 and the World Conference on Disaster Management in May 1994 at **Yokohama**, Japan, etc. are some of the concrete steps towards this direction.

Yokohama Strategy and International Decade for Natural Disaster Reduction (IDNDR) Yokohama Strategy and Plan of Action for a Safer World

All the member states of the United Nations and other states met at the World Conference on Natural Disaster Reduction in the city of Yokohama from May 23rd-27th 1994. It acknowledged that the impact of natural disasters in terms of human and economic losses has risen in recent years, and society, in general, has become vulnerable to natural disasters. It also accepted that these disasters affected the poor and disadvantageous groups the worst, particularly in the developing countries, which are ill-equipped to cope with them. Hence, the conference adopted the Yokohama strategy as a guide to rest of the decade and beyond, to mitigate the losses due to these disasters.

The resolution of the World Conference on Natural Disasters Reduction is as mentioned below:

i. It will note that each country has the sovereign responsibility to protect its citizens from natural disasters;
ii. It will give priority attention to the developing countries, particularly the least developed, land-locked countries and small-island developing states;
iii. It will develop and strengthen national capacities and capabilities and, where appropriate, national legislation for natural and other disaster prevention, mitigation and preparedness, including the mobilisation of non-governmental organisations and participation of local communities;
iv. It will promote and strengthen sub-regional, regional and international cooperation in activities to prevent, reduce and mitigate natural and other disasters, with particular emphasis on:
    a. human and institutional capacity-building and strengthening;
    b. technology sharing: the collection, the dissemination and utilisation of information; and
    c. mobilisation of resources.

It also declared the decade 1990-2000 as the International Decade for Natural Disaster Reduction (IDNDR).

The Sendai Framework for Disaster Risk Reduction 2015-2030

The Sendai Framework is a 15-year, voluntary, non-binding agreement which recognizes that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders. The Sendai Framework is the successor instrument to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters. It is the outcome of stakeholder consultations and inter-governmental negotiations which were supported by the UNISDR upon the request of the UN General Assembly. UNISDR has been tasked to support the implementation, follow-up and review of the Sendai Framework.

The Framework was adopted at the Third UN World Conference on Disaster Risk Reduction in Sendai, Japan, on March 18, 2015. The Sendai Framework for Disaster Risk Reduction 2015-2030 outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks:

- Understanding disaster risk
- Strengthening disaster risk governance to manage disaster risk
- Investing in disaster reduction for resilience and
- Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.

It aims to achieve the substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries over the next 15 years.

We **cannot prevent natural hazards**, which are endemic to our geology, geography, climate, social and cultural settings, but we can **certainly strive to manage crisis** more efficiently so that hazards do not degenerate into disasters. Making a policy or formulating a plan is much simpler compared to its implementation when need arises. Disaster management **needs innovative thinking** and fundamental changes. There is a need to bring new technologies, methods, procedures etc. into the system for better prediction. For instance, IMD (24 hours) & National Centre for medium range and weather forecast (46 hours) predicted 8-16 cm rainfall while the actual rainfall recorded was 94.4cm in Mumbai-05. None of the reports could pick up the intra-city variations in the rainfall.

According to a recent study by the World Bank, 2.25% of the GDP and 12.15% of the revenue of the country were lost due to natural disasters during 1996-2000. Every rupee spent on mitigation saves three to five rupees on relief and rehabilitation.

Constitutionally disaster management as a subject is not mentioned in any of the three lists. Therefore, it comes under residuary powers of the union under entry 97 of the union list. Accordingly, parliament has the competence to legislate on this subject, in one view. But in 2005, the Government of India (GoI) took a defining step by enacting the Disaster Management Act, 2005 by invoking the entry 23 namely 'social security and social insurance, employment and unemployment in the concurrent list because by practice and convention the primary responsibility of managing the disasters rests with the state governments. The salient features of the DMA were that it was a proactive, holistic and integrated approach as opposed to a reactive one. It had the legal authority to respond and take action as demanded by the situation and was backed by an institutional framework. And, last but not the least, it had what its predecessor organisations did not have viz. financial support by the creation of a Response Fund and a Mitigation Fund. There will be a paradigm shift, from the erstwhile relief-centric response to a proactive prevention, mitigation and preparedness-driven approach for conserving developmental gains and to minimize loss of life, livelihood and property.

8.8.1. INSTITUTIONAL ARRANGEMENT

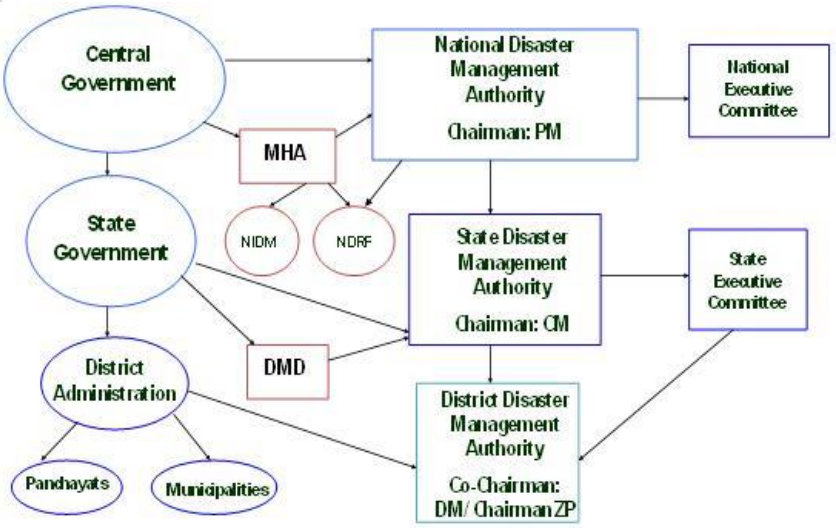
The Disaster Management Act 2005 has provided the legal and institutional framework for disaster management in India at the national, state and district levels. In the federal polity of India the primary responsibility of disaster management vests with the State Governments. The Central Government lays down policies and guidelines and provides technical, financial and logistic support while the district administration carries out most of the operations in collaboration with central and state level agencies.

In the Central Government there are existing institutions and mechanisms for disaster management while new dedicated institutions have been created under the Disaster Management Act of 2005.

The Cabinet Committee on Management of Natural Calamities (CCMNC) oversees all aspects relating to the management of natural calamities including assessment of the situation and identification of measures and programmes considered necessary to reduce its impact, monitor and suggest long term measures for prevention of such calamities, formulate and recommend programmes for public awareness for building up society's resilience to them. The Cabinet Committee on Security (CCS) deals with the matters relating to nuclear, biological and chemical emergencies.

The National Crisis Management Committee (NCMC) under the Cabinet Secretary oversees the Command, Control and Coordination of the disaster response.

The Disaster Management Act, 2005 has created new institutions at the national, state, district and local levels. The new institutional framework for disaster management in the country is as under:



The National Disaster Management Authority (NDMA) under the Chairmanship of the Prime Minister is the apex body responsible for laying down policies, plans and guidelines for disaster management and for coordinating their enforcement and implementation throughout the country. The policies and guidelines will assist the Central Ministries, State Governments and district administration to formulate their respective plans and programmes. NDMA has the power to approve the National Plans and the Plans of the respective Ministries and Departments of Government of India. The general superintendence, direction and control of National Disaster Response Force (NDRF) are vested in and will be exercised by the NDMA.

The National Executive Committee (NEC) is mandated to assist the NDMA in the discharge of its functions and further ensure compliance of the directions issued by the Central Government. The NEC comprises of the Union Home Secretary as the Chairperson, and the Secretaries to the GOI in the Ministries/Departments of Agriculture, Atomic Energy, Defence, Drinking Water Supply, Environment and Forests, Finance (Expenditure), Health, Power, Rural Development, Science and Technology, Space, Telecommunications, Urban Development, Water Resources and the Chief of the Integrated Defence Staff of the Chiefs of Staff Committee as members. Secretaries in the Ministry of External Affairs, Earth Sciences, Human Resource Development, Mines, Shipping, Road Transport & Highways and Secretary, NDMA are special invitees to the meetings of the NEC. The National Executive Committee is responsible to prepare the National Plan and coordinate and monitor the implementation of the National Policy and the guidelines issued by NDMA.

The Ministry of Home Affairs (MHA) in the Central Government has the overall responsibility for disaster management in the country. For a few specific types of disasters the concerned Ministries have the nodal responsibilities for management of the disasters, as under:

Drought	**Ministry of Agriculture**
Epidemics & Biological Disasters	Ministry of Health and Family Welfare
Chemical Disasters	Ministry of Environment & Forests
Nuclear Disasters	Ministry of Atomic Energy
Air Accidents	Ministry of Civil Aviation
Railway Accidents	Ministry of Railways

The National Institute of Disaster Management (NIDM) has the mandate for human resource development and capacity building for disaster management within the broad policies and guidelines laid down by the NDMA. NIDM is required to design, develop and implement training programmes, undertake research, formulate and implement a comprehensive human resource development plan, provide assistance in national policy formulation, assist other research and training institutes, state governments and other organizations for successfully discharging their responsibilities, develop educational materials for dissemination and promote awareness among stakeholders in addition to undertake any other function as assigned to it by the Central Government

The National Disaster Response Force (NDRF) is the specialized force for disaster response which works under the overall supervision and control of the NDMA.

At the State Level the State Disaster Management Authority (SDMA), headed by the Chief Minister, lays down policies and plans for disaster management in the State. It is also responsible to coordinate the implementation of the State Plan, recommend provision of funds for mitigation and preparedness measures and review the developmental plans of the different departments of the State to ensure integration of prevention, preparedness and mitigation measures.

The State Disaster Management Department (DMD) which is mostly positioned in the Revenue and relief Department is the nodal authority.

In the district level the District Disaster Management Authority (DDMA) is headed by the District Magistrate, with the elected representative of the local authority as the Co-Chairperson. DDMA is the planning, coordinating and implementing body for disaster management at district level. It will, inter alia prepare the District Disaster Management Plan and monitor the implementation of the National and State Policies and the National, State and the District Plans. DDMA will also ensure that the guidelines for prevention, mitigation, preparedness and response measures laid down by the NDMA and the SDMA are followed by all departments of the State Government at the district level and the local authorities in the district.

The Local Authorities both the rural local self governing institutions (Panchayati Raj Institutions) and urban local bodies (Municipalities, Cantonment Boards and Town Planning Authorities) These bodies will ensure capacity building of their officers and employees for managing disasters, carry out relief, rehabilitation and reconstruction activities in the affected areas and will prepare DM Plans in consonance with guidelines of the NDMA, SDMAs and DDMAs

8.8.2. CRITICISM

The implementation of the National Disaster Act, 2005 has been slow, and slack. On 22 July 2013 Supreme Court in response to a Public Interest Litigation issued notices to the Governments of Uttarakhand, Tamil Nadu, Odisha, Andhra Pradesh, Gujarat, Rajasthan Maharashtra and the Central government for alleged failure to implement the Disaster Management Act, 2005. The petitioner alleged that the non-implementation of the Disaster Management Act by the Government of Uttarakhand endangered the lives of citizens. He sought "reasonable ex-gratia assistance on account of loss of life, damage to houses and for restoration of means of livelihood to victims of flash floods in Uttarakhand under the Disaster Management Act".

The act has been criticized for marginalizing Non-governmental organizations (NGOs), elected local representatives, local communities and civic group; and for fostering a hierarchical, bureaucratic, command and control, 'top down', approach that gives the central, state, and district authorities sweeping powers. It is also alleged that the "Act became a law almost at the will of the bureaucrats who framed it."

Figure 6 – National Disaster Management structure

A typical **Disaster Management continuum** as shown in figure 7, comprising of **six elements** i.e., **Prevention, Mitigation** and **Preparedness** in pre-disaster phase, and **Response, Rehabilitation** and **Reconstruction** in post-disaster phase, defines the complete approach to Disaster Management.

The '**life cycle'** of disaster management may be divided broadly into three phases-

1. **pre-crisis:** Preparedness
   a. **long term** prevention measures
   b. **short term** measures - disaster education, enforcement of laws,
2. d**uring crisis**: Emergency Response
   a. evacuation
   b. search and rescue
   c. provision of basic needs
3. **post crisis** - 3Rs
   a. recovery
   b. rehabilitation
   c. reconstruction

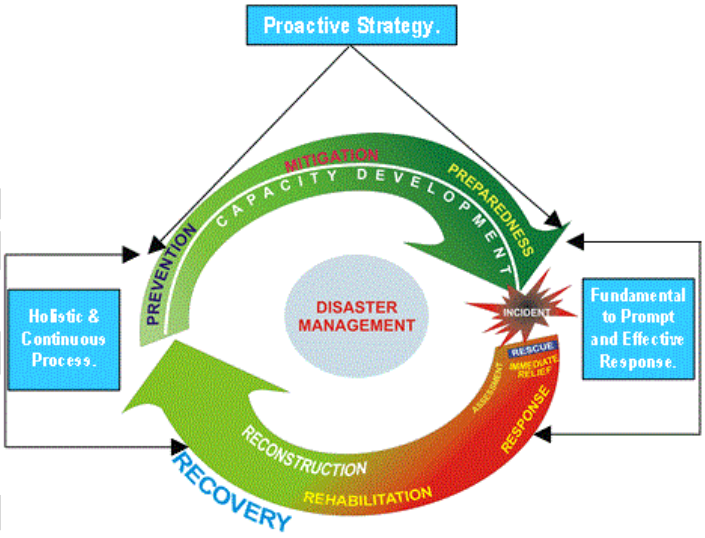


Figure 7: Disaster Management Continuum

8.8.3. SECOND ARC ON NDM ACT 2005

- Disaster/Crisis Management should continue to be the primary responsibility of the State Governments and the Union Government should play a supportive role.
- The Act should provide categorization of disasters (say, local, district, state or national level). This categorization along with intensity of each type of disaster will help in determining the level of authority primarily responsible for dealing with the disaster as well as the scale of response and relief - detailed guidelines may be stipulated by the NDMA on this subject.
- The law should make provisions for stringent punishment for misutilization of funds meant for crisis/disaster management.
- The role of the local governments should be brought to the forefront for crisis/disaster management.

The NEC as stipulated under the Disaster Management Act need not be constituted, and the NCMC should continue to be the apex coordination body. At the state level, the existing coordination mechanism under the Chief Secretary should continue.

8.8.4. DISASTER INSURANCE

Excessive dependence on relief and rehabilitation packages creates a regime where there are **no incentives for adoption of risk reduction**. Insurance is a potentially important mitigation measure in disaster-prone areas as it

brings quality in the infrastructure & consciousness and a **culture of safety** and **culture of prevention.** Disaster insurance mostly works under the premise of 'higher the risk higher the premium, thus creating awareness towards vulnerable areas and motivating people to settle in relatively safe areas.

Following the success of micro-credit for rural development, micro-insurance has started emerging as a tool for ex ante risk management. In fact, micro-credit and micro-insurance support each other. The tool of insurance should be made attractive through a set of policy measures and fiscal incentives. Catastrophic Insurance: Examples from Japan - Seismic Hazard Maps have been put to use and have been found appropriate for modeling financial risk, including time-dependent and time-independent rates of earthquake recurrence.

8.8.5. COMMUNITY BASED DISASTER MANAGEMENT

Disaster management can be effective only if the communities participate in it as community is the repository of knowledge and skills which have evolved traditionally and these needs to be integrated in the management strategy. For example – in recent floods in Chennai, local people were able to help army and other forces in locating the routes as roads were all filled and army was not acquainted with the area as much as locals.

Community is the first line of responders, thus, It is necessary to educate the community and impart skills and assign specific roles regarding disaster management to ensure a coordinated response while disaster. This can be achieved by:

- **Undertaking location specific training programmes for the community**: Cascading approach should be used to impart training as the number of people to be imparted skills are very large. Thus this responsibility can be entrusted at the local level, say, village panchayats
- Disaster management education needs to integrated within the formal and informal systems of education
- The leaders and personnel in critical sectors should be given disaster management training as well
- A proper safety plan including all pre-disaster planning to reduce risk should be made to enhance community preparedness
- The entire process of damage assessment and distribution of the relief packages can be conducted very smoothly with the active involvement of local community leaders and SHGs.

Community also play an important role in recovery process including the socio-psychological rehabilitation of the victims of the disaster as they are more aware about their conditions before the disaster. During the recent past, it has been experienced that the capacity building of the community has been very helpful even in normal situations when isolated instances of drowning, burns etc. take place. With the creation of awareness generation on disaster mitigation and carrying out mock drills from time to time under the close supervision of Disaster Management Committees the community will be able to function as a well-knit unit in case of any emergency.

8.8.6. ROLE OF THE MEDIA IN DISASTER

The role of the media is very important. They are often not provided with the correct information, resulting in the spread of incorrect information which adds to the panic. The disasters are both natural and man-made. But the root causes of some of the seemingly natural disasters may also be certain human activities carried on in utter disregard of their consequences to the nature. Such natural disasters are also therefore preventable. Since all man-made disasters and some of the so called natural disasters are preventable, the media should be used constructively

Pre-disaster

- To educate the community in recognising symptoms and reporting them early if found.
- Ensuring cooperation of the community in risk reduction by forewarning the people about the consequences of their dangerous actions and operations.

During disaster

During the onslaught of the disaster, what is of utmost importance is to keep the morale of the people high, to create self-confidence in them, to prevent panic and to maintain order by assuring and making available the necessary help readily and quickly. The media can help, in many ways in ensuring these conditions.

- Communicating the information to the people and the concerned authorities sufficiently in advance to enable them to take the necessary steps to prevent and minimize the losses of lives and property.

- Playing the role of relaying the measures that are being taken and monitoring them
- Cautioning the affected or to be affected people about the Dos and Don'ts, of scotching rumours and preventing panic and confusion
- Identifying the needy spots and focusing attention on them
- Assisting the authorities, voluntary organizations and volunteers in reaching, informing and assuring the affected ones of the assistance and the measures taken, for their relief.

Post-disaster

- Collection of material resources and the enlisting of man-power by appealing to the people to come forward to render help. Many times, the depiction of devastation and of human misery through the by itself acts as an appeal
- Helping the affected in establishing contacts with their closed ones
- Keeping a watch and report on some anti-social elements who try to take advantage of such situations
- Contributing by countering the damaging, exaggerated and negative reporting and propaganda in the foreign media on the occurrence of the disasters. A prompt presentation of the real state of affairs by our media including the news-agencies, and the correction of the misrepresentations by them will go a long way in dispelling the wrong impressions created abroad which may otherwise have adverse effect on the administration, the economy and the polity of the country.

Almost always, the worst sufferers are the weaker sections of the society. They are unable to shift from these places, because there lie their sources of livelihood and all that they have in life to preserve and protect. They constitute a vast section of our society. Yet, except in the times of disaster, they are rarely remembered and the measures for the permanent solution of their plight are hardly ever discussed in the media. The media can also focus its attention on this problem.

Role of Social Media

Unbelievable as it sounds, PWD officials created a WhatsApp group and that acted as the main tool of communication for sharing information during the devastating Hudhud cyclone that struck Visakhapatnam. No meetings and discussions were organised at the district level as the WhatsApp group helped identify and access required resources

This case reveals the potential of social media to be used in tackling the challenges posed by natural calamities. Following hudhud cyclone post-disaster damage assessment showed how social media was effective in communicating the exact location of breach of road or fallen trees, identifying the required resources and request for tools and JCBs etc. to the concerned person directly using Whatsapp group.

Social media has become a part of our daily lives and is a very powerful tool for emergency management if used properly. Social media and pre-designed apps are effective when written reports and formal meetings are not required. During our current road to resilience mission we learned about the use of social media during the Chennai flooding last year.

8.9. NATIONAL POLICY ON DISASTER MANAGEMENT

NDMA came up with a '**national policy on Disaster Management'** (NPDM) in 2009. It is prepared in tune with and in pursuance of the Disaster Management Act, 2005 with a vision to build a safe and disaster resilient India by developing a holistic, proactive, multi-disaster oriented and technology driven strategy through a culture of prevention, mitigation, preparedness and response. The Policy covers all **aspects of disaster management** such as:

- Covering institutional, legal and financial arrangements
- Disaster prevention, mitigation and preparedness, techno-legal regime
- Response, relief and rehabilitation
- Reconstruction and recovery
- Capacity development
- Knowledge management and research and development

The NPDM addresses the concerns of all the sections of the society including differently abled persons, women, children and other disadvantaged groups. The NPDM aims to bring in transparency and accountability in all

aspects of disaster management through involvement of community, community based organizations, Panchayati Raj Institutions (PRIs), local bodies and civil society.

8.10. CURRENT DEVELOPMENTS

8.10.1. RETROFITTING OF BUILDINGS – THE KEY IS TO LET IT SWING

Parameters for earthquake-resistant construction have been laid down in Indian Standards Code, 2002, which has been periodically updated. It entails studying a building's design and assessing its construction material by non-destructive radiological tests.

The key idea of making a building earthquake-resistant is to make it ductile, i.e. to give it a certain flexibility to shake horizontally. It helps soften the impact of the earthquake and lets the building absorb its energy.

To make a building earthquake resistant, its base is strengthened in a way that during an earthquake, the building's load is borne by the base alone, and upper stories do not experience much quaking. The part of the base that is above the ground is cut and rested on bearings, exactly like how a jack is used to lift a car to change wheels. The bearings act as shock absorbers, similar to those in cars. Adding rubber material such as used tyres to the foundation of a building under construction can also be done.

Symmetrical structures such as a square, circle or rectangle are less vulnerable and easier to retrofit.

For a building under construction, the cost is estimated to increase by about 10% and for retrofitting, it is estimated to be around 15-20% of the total cost of the structure.

8.10.2. CHANGE IN OPERATIONS AFTER ESTABLISHMENT OF NDRF

Earlier (for e.g. during Bhuj EQ), it was bulldozers and earth movers that hauled debris, rescuers employed eyes and ears and sniffer dogs to search for people – living or dead, and to manually pull them out. This has undergone drastic improvement, both in terms of technology and specialized training. Rescue operations in quake hit areas are a highly sophisticated exercise, known as CSSR – Collapsed Structures Search and Rescue.

Locating survivors is technology driven – thermal sensors and heartbeat detectors can find survivors 40-50 feet beneath the rubble. It even can distinguish between a human and an animal. Modern equipment can cut through concrete quickly and precisely. Once a survivor is located, a 15-20 foot hole (triangular since bricks hold well in this shape) can be drilled to lower a camera. A video conversation can infuse hope in the victim; urge him/her not to give up.

Once cutting begins, rescuers take precaution that debris does not fall inside. Smoke is also sucked up, so that it does not suffocate the trapped.

NDRF, established in 2006, is now considered the world's single largest dedicated disaster response force, with best technology and advanced training. It can tackle all disasters, including CBRN – Chemical, Biological, Radiological and Nuclear emergencies. Its capabilities match the most stringent international standards. It is in line to get certifications from International Search and Rescue Advisory Group, a global network of rescue forces under the UN.

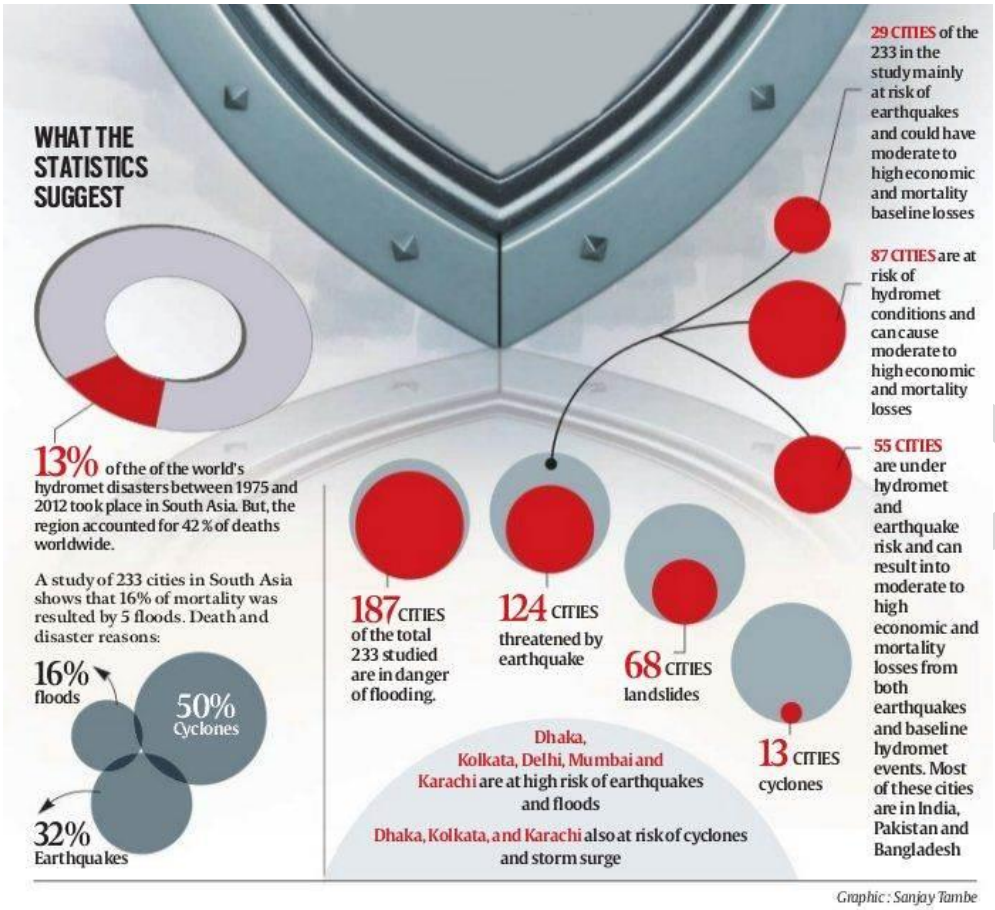
8.10.3. Developing Disaster Proof Cities

At least 38 cities in India lie in the high-risk seismic zones; ~60% of the sub-continental landmass is immensely vulnerable to various natural disasters. The fact the large section of population is poor and lives in houses and cities that are hastily built and are not earthquake resistant raises the risk of human impact, in case of any natural disaster.

The urban planning in India, especially the SMART cities project and AMRUT mission should take into account topography and vulnerability of areas to various hazards. A World Bank report on urbanization in South Asia outlines the need for government to plan for more resilient cities and to plan holistically to deal with risks arising out of growing population density. It enlists four recommendations for policymakers:-

- **Identify** risk by using Urban Risk Assessment framework
- **Mitigate** risk by planning critical and multipurpose safe and resilient infrastructure

- **Develop a Risk Financing Scheme** to provide immediate liquidity in the aftermath and to build financial resilience
- Build **Strong Institutions** and **collect, share and distribute data.**



Developing Disaster Proof Cities

Urban population in South Asia is projected to grow by about 300 million between 2011 and 2030. Unplanned migration has resulted in concentration of poor population in risk-prone areas, Deltas, flood-plains and coasts are most vulnerable. According to the report:-

- 80% of major South Asian cities are exposed to floods.
- More than half of future expansion would be in flood-prone areas
- From reactive planning, cities are moving towards anticipatory planning by integrating DRM (Disaster Risk Management) into their national planning framework
- Further steps required: Spatial planning and creating of formal land markets that limit unplanned development.

Planning for Disaster Summarized – Developing a resilience strategy

1. **Identification of**
   - Risks at national and city level
   - Vulnerabilities of communities and potential exposure to disasters
   - Critical infrastructure to develop early warning systems
2. **Mitigation** through both structural and non-structural methods
   - **Structural measures –** check dams, wave barriers, retrofitting buildings, etc.
   - **Non-Structural measures –** Building codes, land-use planning, Public awareness
   - City authorities should provide incentives to follow building codes as it would reduce post-disaster costs.
   - Empowerment of city leaders
3. **Financing the Risk**
   - **Advanced Financing Plan –** include reserves, calamity funds, budget contingencies, contingent debt facilities and risk transfer mechanisms.
   - **Traditional Instruments –** Insurance, reinsurance and parametric insurance

- **Alternative Risk transfer instruments –** Catastrophe bonds – Required for major disasters
- **Example – Sri Lanka** – Has a catastrophe draw down option with assistance from World Bank, which provides a line of credit in case of such events.

8.11. UPSC PREVIOUS YEARS MAINS QUESTIONS

1. Composition and functions of the National Executive Committee of the National Disaster Management Authority. (2011/5 Marks)
2. Write note on Causes of droughts in India. (UPSC 2005/2 Marks)
3. Which parts of India were mainly affected by the severe drought of 1987-88? What were its main consequences? (88/II/6b/20)
4. Why are floods such a recurrent feature in India? Discuss the measures taken by the Government for flood control. (85/II6c/20)
5. Drought has been recognized as a disaster in view of its spatial expanse, temporal duration, slow onset and lasting effects on vulnerable sections. With a focus on the September 2010 guidelines from the National Disaster Management Authority (NOMA), discuss the mechanisms for preparedness to deal with likeJy EI Nino and La Nina fallouts in India. (2014)
6. How important are vulnerability and risk assessment for pre-disaster management ? As an administrator, what are key areas that you would focus on in a Disaster Management System.

GM CROPS

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9. GM CROPS

9.1. WHAT IS GM FOOD?

- According to the World Health Organization (WHO), genetically modified (GM) foods are foods derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, e.g. through the introduction of a gene from a different organism.
- Currently available GM foods stem mostly from plants, but in the future foods derived from GM microorganisms or GM animals are likely to be introduced on the market.
- Most existing genetically modified crops have been developed to improve yield, through the introduction of resistance to plant diseases or of increased tolerance of herbicides.

9.2. TECHNOLOGY BEHIND GM CROPS

- The technology is often called "modern biotechnology" or "gene technology", sometimes also "recombinant DNA technology" or "genetic engineering".
- It allows selected individual genes to be transferred from one organism into another, also between nonrelated species.
- The resulting organism is said to be genetically modified, genetically engineered, or transgenic.
- Resistance against insects is achieved by incorporating into the food plant the gene for toxin production from the bacterium Bacillus thuringiensis (Bt). This toxin is currently used as a conventional insecticide in agriculture and is safe for human consumption. GM crops that inherently produce this toxin have been shown to require lower quantities of insecticides in specific situations, e.g. where pest pressure is high.
- Virus resistance is achieved through the introduction of a gene from certain viruses which cause disease in plants. Virus resistance makes plants less susceptible to diseases caused by such viruses, resulting in higher crop yields.
- Herbicide tolerance is achieved through the introduction of a gene from a bacterium conveying resistance to some herbicides. In situations where weed pressure is high, the use of such crops has resulted in a reduction in the quantity of the herbicides used.

9.3. ISSUES OF CONCERN

- The capability of the GMO to escape and potentially introduce the engineered genes into wild populations.
- The persistence of the gene after the GMO has been harvested.
- The susceptibility of non-target organisms (e.g. insects which are not pests) to the gene product.
- The reduction in the spectrum of other plants including loss of biodiversity.
- The environmental safety aspects of GM crops vary considerably according to local conditions.
- The food may cause harm to other organisms.
- Genetically modified crops could inadvertently crossbreed with other crops.
- Insects might become resistant to the toxins produced by genetically modified crops.
- The food could make disease-causing bacteria that are resistant to antibiotics.
- **Are GM Foods safe?**
  - Different GM organisms include different genes inserted in different ways.
  - This means that individual GM foods and their safety should be assessed on a case-by-case basis and that it is not possible to make general statements on the safety of all GM foods.
- **Potential developments in future**
  - Future GM organisms are likely to include plants with improved resistance against plant disease or drought, crops with increased nutrient levels, fish species with enhanced growth characteristics.
  - For non-food use, they may include plants or animals producing pharmaceutically important proteins such as new vaccines.
- **Arguments in support of GM crops**
  - In the wake of rising population, many scientists believe that GM crops can assist significantly in ensuring food security.
  - GM food crops have been altered to have shorter growing cycles, stronger resistance to both insects and disease, and produce higher yields.
  - In addition, some say these foods are also more nutritious and have a longer shelf life.

- **Arguments against GM crops**
  - Bt cotton has failed in rain fed areas which represent two-thirds of cotton growing areas; it has succeeded only in irrigated areas.
  - Concurrently with the consumption of GM food, there has been increase in the incidence of gastrointestinal tract disorders and cases of allergy in US. This, of course, does not establish a cause and effect relationship between consumption of GM food and health problems mentioned above, but it certainly makes it possible.
  - We produce more food today without the use of GM technology than is required to feed the world population, and we do not need GM technology to take care of future food requirements. In India, as much as 40 per cent of food we produce is wasted.
  - We have virtually no testing of GM crops for safety. In the US, they are approved on the basis of just "substantial equivalence" with the non-GM material.
  - Tests carried out so far have not been done by an independent body; they have been done by the company intending to market the product.
  - In our country, in no case has field trials of GM crops been adequately and appropriately supervised.
- **Difference between GM crops and traditional breeding**
  - Traditional breeding involves crossing two organisms usually within the same species to combine desirable characteristics.
  - On the other hand in modern biotechnology, desired genes can be inserted into a non-related individual, so the DNA is recombined.
- **Regulatory mechanism**
  - The two-tier regulatory framework for GM crops includes a Review Committee on Genetic Manipulation (RCGM) under Department of Biotechnology and the Genetic Engineering Appraisal Committee (GEAC) under the MoEF.
  - The GEAC considers proposals for trial only after approval from the RCGM, a body comprising scientists well versed with the technology.
  - GEAC is the apex body in India that is authorized to approve the use of genetically modified crops or organisms in the country.
  - GEAC is a statutory body required to meet at least once each month; however, the body has only met eight times in the last three years and had not considered any agri-biotechnology applications since August 2014.

9.4. INTERNATIONAL CONVENTIONS

- The Cartagena Protocol on Biosafety was adopted by the CBD and came into force in 2003. In the case of genetically modified plants, it particularly regulates trans-boundary movement. The Protocol details specific requirements for the handling, labelling, packaging, and transportation of genetically modified plants. It also requires registration of all relevant information with the Biosafety Clearing House, an international mechanism established under the Protocol.
- International Plant Protection Convention (IPPC) has identified potential pest risks that may need to be considered regarding GMO's, including new genetic characteristics that may cause invasiveness, gene flow, and effects on non-target organisms (beneficial insects or birds).

9.5. GM MUSTARD

- Mustard DMH-11 (Dhara Mustard Hybrid 11), a genetically modified (GM) mustard hybrid is a transgenic crop developed by Centre for Genetic Manipulation of Crop Plants at Delhi University. The team was led by former vice-chancellor Deepak Pental.
- The resulting GM mustard hybrid, it is claimed, gives 25-30 per cent more yield than the best varieties such as 'Varuna' currently grown in the country.
- Hybrids are normally obtained by crossing two genetically diverse plants from the same species. The first-generation offspring resulting from it has higher yields than what either of the parents is individually capable of giving.
- But there is no natural hybridisation system in mustard, unlike in, say, cotton, maize or tomato. This is because its flowers contain both the female (pistil) and male (stamen) reproductive organs, making the plant naturally self-pollinating.
- Therefore, it has been created using GM technology.

9.5.1. ARGUMENTS IN SUPPORT OF GM MUSTARD

- In 2014-15, India imported 14.5 million tonnes of edible oils valued at $10.5 billion. Therefore, the need to raise domestic crop yields and cut dependence on imports cannot be doubted.
- Hybrid technology is a potential technique to boost yields, as has been successfully demonstrated in a host of crops.
- Country's cotton production has gone up more than 2½ times since Bt hybrids were first planted in 2002. Nor has any evidence emerged really of Bt cotton causing any adverse human or animal health effects.
- India annually imports 3 million tonnes of soyabean oil and another 0.4 million tonnes of rapeseed oil, which are predominantly GM.
- Delhi University's CGMCP has pledged to distribute the GM mustard for free.

9.5.2. TECHNOLOGY BEHIND GM MUSTARD

- It has been created using GM technology, involving incorporation of "**Barnase**" gene isolated from a soil bacterium called Bacillus amyloliquefaciens.
- It codes for a protein that impairs pollen production and renders the plant into which it has been introduced male-sterile.
- This male-sterile plant is crossed with a fertile parental line, containing, in turn, another gene, "Barstar", from the same bacterium that blocks the action of the "Barnase" gene.
- The resultant progeny, having both the foreign genes, is a hybrid mustard plant that is not only high-yielding, but also fertile and capable of producing seed/grain.

9.5.3. ARGUMENTS AGAINST GM MUSTARD

- Much-touted GM cotton had failed to deliver despite claims to the contrary.
- Opting for GM food without proper verification may impact the safety of the consumers.
- Livelihood of millions of farmers in the country may also get affected.
- If the GM food crops were to be introduced, the MNCs could monopolise the food market affecting food and nutrition security of the country.

9.5.4. REGULATORY ENVIRONMENT NEEDS REFORM

- There is lack of transparency as well as conflict of interest in the system.
- There are multiple committees — at least six — that are part of the current regulatory structure.
- The Genetic Engineering Approval Committee, which is responsible for approving large-scale releases and commercialisation of GMOs, functions under the Ministry of Environment and Forests and is not entirely independent.
- The case of the Review Committee on Genetic Manipulation that supervises and clears research activities and also small-scale field trials is even starker. It is part of the Department of Biotechnology, whose primary task is to promote biotechnology. DBT therefore is the promoter as well as the regulator.
- On several occasions, developers of transgenic crops have also been members of regulatory committees.

9.5.5. RECENT DEVELOPMENTS

- Activists and protesters, under the banner 'Sanson Satyagraha' held a symbolic protest outside the Environment Ministry and demanded the government not to proceed with the process of the environmental release application of GM mustard.
- The Genetic Engineering Appraisal Committee (GEAC), the apex body to accord approval for large-scale use and commercial release of genetically modified organisms in India, discussed safety issues of GM mustard's application, but refrained from taking a final decision.
- The GEAC is constituted by the Environment Ministry.
- Besides suggesting eight additional bio-informatic tests for inclusion in the seed's biosafety dossier, the GEAC asked the Centre for Genetic Manipulation of Crop Plants (CGMCP) to prepare a Risk Assessment and Risk Management (RARM) document.

9.5.6. SUPREME COURT

- The Supreme Court has sought an explanation from the central government on its proposed move to introduce herbicide resistant mustard, cotton and corn in the face of a court-imposed ban on their introduction.
- The top court had in a series of orders passed in February 2007, April 2008 and August 2008 sought to restrain both small-scale and large-scale field trials in any food crops as well as their commercial introduction in the country.
- Petitioner in the court, Aruna Rodrigues said the government wilfully and deliberately not only conducted small-scale field trials but also large-scale field trials for commercial introduction of herbicide tolerant crops of mustard, cotton and corn in India for the first time.
- The risk of contamination from GM mustard and corn is of an unprecedentedly high order and proven in other cases involving Canada, Japan and Mexico (corn) and US (rice), the petition said.

9.5.7. CONCLUSION

- There is need of an independent biotechnology regulatory authority, a single organisation that will replace the multiple committees. This authority should deal with the use of all GMOs in agriculture, pharmaceutical and biodiversity sector.
- While research and scientific development should continue, GM mustard should be allowed in the public domain only after proper verification that it will not cause any irreversible damage to the environment and public at large.

9.6. PREVIOUS YEAR PRELIMS QUESTIONS

1. "Other than resistance to pests, what are the prospects for which genetically engineered plants have been created? (2012)

1. To enable them to withstand drought.
2. To increase the nutritive value of the produce.
3. To enable them to grow and do photosynthesis in spaceships and space stations.
4. To increase their shelf life.

Select the correct answer using the codes given below:

(a) 1 and 2 only (b) 3 and 4 only
(c) 1, 2 and 4 only (d) 1, 2, 3 and 4"

Answer: (d)

2. A genetically engineered form of brinjal, known as the Bt-brinjal, has been developed. The objective of this is (2011)

(a) To make it pest-resistant (b) To improve its taste and nutritive qualities
(c) To make it drought-resistant (d) To make its shelf-life longer

Answer: (a)

3. Genetically modified "golden rice" has been engineered to meet human nutritional requirements. Which one of the following statements best qualifies golden rice? (2010)

(a) The grains have been fortified with genes to provide three times higher grain yield per acre than other high yielding varieties
(b) Its grains contain pro-vitamin A which upon ingestion is converted to vitamin A in the human body
(c) Its modified genes cause the synthesis of all the nine essential amino acids
(d) Its modified genes cause the fortification of its grains with vitamin D.

Answer: (b)

4. Mon 863 is a variety of maize. It was in the news for the following reason: (2010)

(a) It is a genetically modified dwarf variety which is resistant to drought
(b) It is a genetically modified variety which is pest resistant
(c) It is a genetically modified variety with ten times higher protein content than regular maize crop
(d) It is a genetically modified variety used exclusively for bio - fuel production

Answer: (b)

5. Which one of the following statements is correct? (2005)

(a) The First Meeting of the Parties (MOP 1) to the Cartagena Protocol on Biosafety was held in Philippines in the year 2004

(b) India is not a signatory to the Biosafety Protocol/Convention on Biological Diversity

(c) The Biosafety Protocol deals with genetically modified organisms

(d) The United States of America is member of the Biosafety Protocol/Convention on Biological Diversity

Answer: (c)

6. The Genetic Engineering Approval Committee, whose permission is required for cultivation of any genetically modified crop such as Bt-Cotton in India, is under the Union Ministry of (2003)

(a) Agriculture (b) Environment and Forests

(c) Commerce and Industry (d) Rural Development

Answer (b)

7. Insect-resistant cotton plants have been genetically engineered by inserting a gene from a/an: (2000)

(a) Virus (b) Bacteria

(c) Insect (d) Plant

Answer (b)

Previous Year Mains Question:

1. The human population is slated to grow to 9 billion by 2050. In this context, many scientists predict that plant genomics would play a critical role in keeping out hunger and preserving the environment. Explain. (2012)

SUSTAINABLE HABITAT GREEN BUILDING NORMS IN INDIA

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10. SUSTAINABLE HABITAT

We shape our buildings, thereafter they shape us.

India's ancient buildings speak of a civilization that believed in a spiritual connect with the nature. Its forts, palaces and homes were built in harmony with nature and very often with limited wastage of resources. Over the last century, as buildings reached higher into the sky and became a symbol of modernity and progress, somewhere along the way they also become detrimental for the earth's climate. The following facts demonstrate this:

- 40 % of the energy related global emissions are attributed to buildings.
- 60 % of waste comes from building or related activities.

10.1. SUSTAINABLE BUILDINGS/GREEN BUILDINGS

- Green building design strives to balance environmental responsibility, resource efficiency, occupant comfort and well-being, and community sensitivity.
- TERI, a not-for profit organization working in the field of sustainable development, defines it as "A Green building is designed, constructed and operated to minimize the total environmental impacts while enhancing user comfort and productivity".
- The Indian Green Building Council, part of Confederation of Indian Industry (CII), provides the following definition - "A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building."
- Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:
    - Efficiently using energy, water and other resources.
    - Protecting occupant health and improving employee productivity.
    - Reducing waste, pollution and environmental degradation.

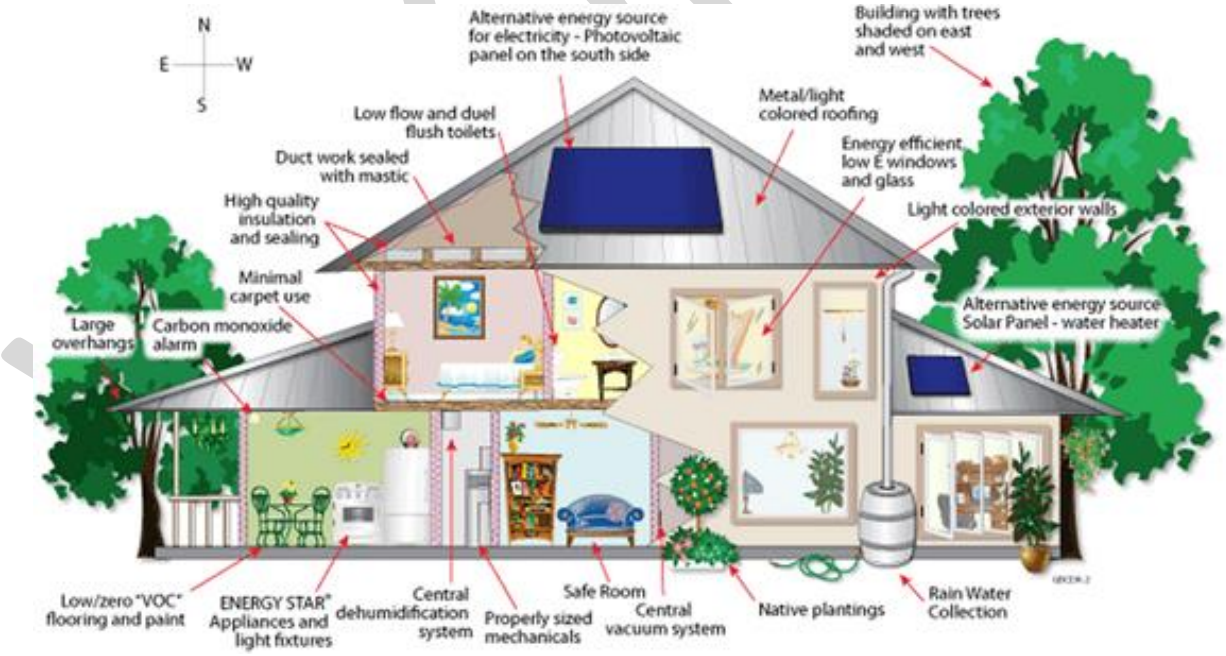

Figure : A typical green building

- The benefits of sustainable design include:
    - **Environmental**: Structures built on the sustainable design model place minimal impact on the environment. This is accomplished through the prudent use of resources and by deploying systems for recycling and renewable energy sources such as solar power and wind energy.
    - **Financial**: Sustainability principles integrated early within the design, offer improved life cycle costs as

compared to conventional buildings due to reduced maintenance and replacement. Additional cost savings are obtained through the use of recycling systems and renewable energy sources.

- **Social**: The availability of improved air quality and natural light helps boost employee morale and productivity. Reduced strain on resources increases the availability of those resources within the specific eco-systems and geographical regions.

In a nutshell, sustainable buildings use less energy and water, generate less greenhouse gases, use materials more efficiently, and produce less waste than the conventional buildings over their entire life cycle.

10.2. ASSESSMENT TOOLS AND RATING SYSTEMS

A number of organisations have developed standards, codes and rating systems that let government regulators, building professionals and consumers embrace green building with confidence. In some cases, codes are written so local governments can adopt them as bylaws to reduce the local environmental impact of buildings. Building rating systems are a popular tool to bring momentum in achieving energy efficiency and sustainability in buildings. The country has currently two rating systems namely, **LEED and GRIHA**.

Leadership in Energy and Environmental Design (LEED): The LEED Green Building Rating System, developed and managed by the USGBC (U.S. Green Building Council (a private company)), is the most widely used rating system in North America. Buildings are given ratings of platinum, gold, silver, or "certified", based on green building attributes.

The Indian Green Building Council (IGBC), part of the Confederation of Indian Industry (CII) was formed in the year 2001. The vision of the council is, "To enable a sustainable built environment for all and facilitate India to be one of the global leaders in the sustainable built environment by 2025.

Currently, IGBC is facilitating the LEED rating of the U.S. Green Building Council in India. LEED-India was launched in 2001 and rates buildings on environmental performance and energy efficiency during the design, construction and operation stages.

10.3. GRIHA

- **TERI** has developed GRIHA (Green Rating for Integrated Habitat Assessment), which was adopted as the national rating system for green buildings by the Government of India in 2007.
- It evaluates the environmental performance of a building holistically over its entire life cycle, thereby providing a definitive standard for what constitutes a 'green building'.
- GRIHA attempts **to minimize a building's resource consumption, waste generation, and overall ecological impact** to within certain nationally acceptable limits / benchmarks.
- GRIHA currently operates under ADaRSH (Association for Development and Research on Sustainable Habitats (*read ahead*)).
- GRIHA attempts to minimize a building's resource consumption, waste generation, and overall ecological/ environmental impact by comparing them to certain nationally acceptable limits / benchmarks. It does so, adopting the five 'R' philosophy of sustainable development. It includes:
  - **Refuse**–to blindly adopt international trends, materials, technologies, products, etc. Specially in areas where local substitutes/equivalents are available
  - **Reduce**–the dependence on high-energy products, systems, processes, etc.

- **Reuse**–materials, products, and traditional technologies, so as to reduce the costs incurred in designing buildings as well as in operating them
- **Recycle**–all possible wastes generated from the building site, during construction, operation and demolition
- **Reinvent**–engineering systems, designs, and practices such that India creates global examples that the world can follow rather than us following international examples.

GRIHA Criteria: The set of 34 GRIHA criteria are broadly classified into four categories

1. Site Selection and Site Planning
2. Building Planning and Construction
3. Building Operation and Maintenance
4. Innovation

These four categories are further classified into mandatory, optional, applicable and selectively applicable.

10.3.1. GRIHA CERTIFICATION

All buildings in the design stage, except for industrial complexes and housing colonies, are eligible for certification under the TERI GRIHA system as follows:

Points Scored	Rating
50 -60	*
61-70	**
71-80	***
81-90	****
91-100	*****

Association for Development and Research of Sustainable Habitats (ADaRSH)

- ADaRSH is an independent platform (registered as a society) for the interaction on scientific and administrative issues related to sustainable habitats in the Indian context. It was founded jointly by MNRE (Ministry of New and Renewable Energy, Government of India) and TERI (The Energy and Resources Institute, New Delhi) along with experts in the fields related to sustainability of built environment from across the country. ADaRSH promotes GRIHA—The National Rating System (Green Rating for Integrated Habitat Assessment) as a design and evaluation tool for Green Buildings and Habitats.
- All activities related to issuance of GRIHA rating are carried out by ADaRSH. Below are given some of the activities:
- **GRIHA Pre-certification:** Pre-certification is also awarded to upcoming projects based on their commitment to comply with GRIHA. In accordance with the office memorandum by the Ministry of Environment and Forests (MoEF), GRIHA pre-certified projects are eligible to fast track environmental clearance.
- **SVA GRIHA**: As a variation of GRIHA, ADaRSH has developed SVA (Simple Versatile Affordable) GRIHA for rating of smaller projects. SVAGRIHA has been designed as an extension of GRIHA and has been specifically developed for projects with built-up area less than 2500 sq. m.
- **GRIHA LD (Large Developments):** ADaRSH is launching GRIHA LD rating system for planning green large developments like green campuses, townships, and special economic zones. ADaRSH is accepting pilot projects to test the draft guidelines in various contexts.
- **Capacity-building initiatives for operationalizing the rating system:** ADaRSH conducts awareness workshops on Green Buildings and GRIHA rating system. It also organizes training of trainers and evaluators as design and development of Green Infrastructure necessitates large pool of qualified professionals in all parts of the country.